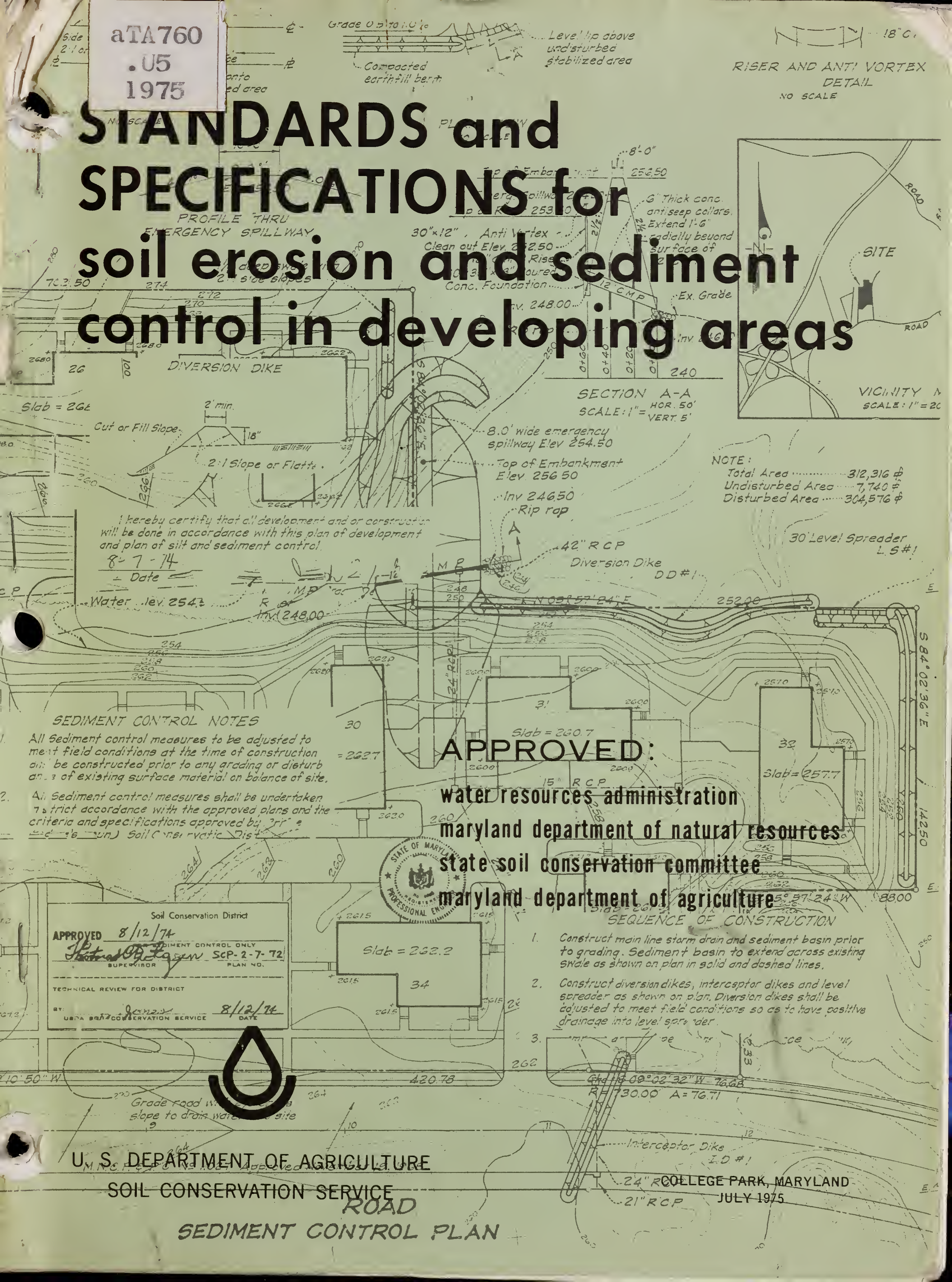
STANDARDS and SPECIFICATIONS for soil erosion and sediment control in developing areas



APPROVED:

water resources administration

maryland department of natural resources

state soil conservation committee

maryland department of agriculture

U. S. DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

COLLEGE PARK, MARYLAND

JULY 1975

STANDARDS AND SPECIFICATIONS

for

Soil Erosion and Sediment Control

in

Developing Areas

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PREFACE

This assembly of standards and specifications has been prepared by the Soil Conservation Service in providing technical assistance through the Soil Conservation Districts in Maryland. It is provided to promote uniformly high technical quality in the selection, design, installation and maintenance of erosion and sediment control measures. It replaces "Standards and Specifications for Soil Erosion and Sediment Control in Urbanizing Areas", 1969, U. S. Soil Conservation Service, College Park, Maryland.

The November 1969 interim standards and specifications were completed by the Soil Conservation Service in Maryland as a part of the technical assistance in soil, water, and related resource conservation to Soil Conservation Districts through local memoranda of understanding. Many of these standards and specifications originated in the Montgomery Soil Conservation District through its broadly based sediment control task force. These were subsequently further developed based on experience and inputs from numerous persons involved in the pioneer sediment control programs in Montgomery, Prince Georges, Baltimore, Howard and Anne Arundel Soil Conservation Districts and Counties in Maryland and the Fairfax County portion of the Northern Virginia Soil and Water Conservation District. These standards and specifications were further tested during the implementation of the Patuxent River Watershed Sediment Control Law of 1969 and they were made available in quantity in the implementation of the Maryland 1970 Sediment Control Law. They were subsequently approved and adopted by the Water Resources Administration of the Maryland Department of Natural Resources, the Soil Conservation Districts in Maryland, the State Highway Administration, Baltimore City, Baltimore Gas and Electric Company, Washington Suburban Sanitary Commission and many others. More than 5,000 copies have been distributed by the Water Resources Administration and the Soil Conservation Service.

The need for revising and expanding the 1969 issue became apparent about three years ago based on the many suggestions from those who used it in the development, design, review, approval, installation, and inspection of sediment control plans and measures.

Because of prior inputs from Virginia and also to aid those developers and consultants working across state lines, a joint SCS committee from Maryland, Virginia and the District of Columbia cooperated in preparing an initial draft. In doing this, they consulted with many local and state agencies, organizations and individuals in both states.

After receiving comments a committee of the most experienced technicians in the Soil Conservation Service in Maryland along with representives of the Water Resources Administration compiled this new issue. Prior to printing, it was submitted to the Water Resources Administration and the State Soil Conservation Committee for their review and approval.

We hope this background information will help to illustrate the evolution of "Standards and Specifications for Soil Erosion and Sediment Control in Developing Areas" and encourage interested persons to contribute their experiences and knowledge in a continuing process of improvement.

– THE DREAM –
CLEAN WATER AND A STABLE STREAM

UNDERSTANDING THE SOIL AND OTHER NATURAL RESOURCES AIDS PLANNING FOR EROSION AND SEDIMENT CONTROL

A SOIL MAP LIKE THIS ALONG WITH INTERPRETIVE DATA IS AVAILABLE FOR EACH ACRE IN MARYLAND

INTRODUCTION

Understanding the Problem

Sedimentation involves three basic processes --- erosion, transportation, and deposition. These are natural geologic phenomena that have been in continuous operation for millions of years. Man's land development activities, however, have initiated severe, highly undesirable and damaging alterations in the natural sedimentation cycle, particularly in local areas, by drastically accelerating the erosion-sedimentation process.

Erosion

The process of soil erosion by water on upland areas involves detachment from the soil mass, transportation primarily by flowing water, and eventual deposition of at least the larger particles of the sediment. Soil is detached by raindrop impact and by runoff shear forces, but man's activities often loosen and pulverize soil, thereby making it more easily moved by rainfall and runoff. Downslope transportation of soil particles is primarily by channelized runoff, although raindrop splash causes some net downslope movement and increases the transport capability of unchannelized overland flow. Significant runoff does not occur until the rainfall intensity is greater than the soil infiltration rate, but once runoff begins, the quantity and size of material that can be transported is a function of runoff velocity and turbulence. Deposition of eroded sediment may occur when the velocity or turbulence of runoff decreases significantly. Deposition is normally a quite selective process with the largest and densest particles settling out first and the finer particles being carried farther. Therefore the size distribution of the eroded material is important in determining the portion of the sediment load deposited and the composition of the material remaining in the runoff. Dispersed colloidal-sized particles remain in suspension for extended periods of time.

Soil eroded from upland areas comes from locations of channelized flow called rills and from sheet erosion above and between rills. Sheet erosion is not greatly influenced by slope steepness or location on a slope. Rill erosion primarily results from the effects of runoff, and it is greatly influenced by slope and flow rate.

Different soils and different soil surface conditions greatly influence their susceptibility to soil detachment by rainfall, soil transport by rainfall, soil detachment by runoff, and soil transport by runoff (1).

The principal effect land development activities have on the natural or geologic erosion process consists of exposing disturbed soils to precipitation and to surface storm runoff. Shaping of land for construction or development purposes alters the soil cover and the soil in many ways, often detrimentally affecting on-site drainage and storm runoff patterns and, eventually, off-site stream and streamflow characteristics. Protective vegetation is reduced or removed, excavations are made, topography is altered, the removed soil material is stockpiled - often without protective cover - and the physical properties of the soil itself are changed. The energy responsible for

erosion is provided by falling rain and by the movement of surface storm runoff. Raindrops strike the ground with a velocity of approximately 30 feet per second --- like minature bombs!

These raindrops break individual soil particles loose and surface runoff then carries the particles downslope. The impact of rain falling onto exposed soil for a period of from one to four minutes is known in many instances to have decreased infiltration to such an extent, even on some sandy soils; that up to 98 percent of the rainfall thereafter runs off (2).

Sedimentation

Surface storm runoff moves as sheet flow or becomes concentrated in rills and gullies. It is dynamic in that it has energy to erode and transport soil particles --- sediment. If the available energy is greater than the burden of the sediment load being transported, the moving water will erode the soil to obtain additonal sediment; if the load is greater, deposition of some of the transported material will occur. Normally, runoff builds up rapidly to a peak and then diminishes. Excessive quantities of sediment are derived by erosion principally during the higher flows. During lower flows, as the velocity of runoff decreases, the transported materials are deposited to be picked up by later peak flows. In this way, sediments are carried downslope, or downstream, intermittantly and progressively from their source area or point of origin.

A study of sedimentation due to highway construction and land development in Virginia, for instance, indicated that 99 percent of the sediment discharge occurred during periods of high flow which took place during only 3 percent of the period of measurement (3).

Sediment Damage -

Over four billion tons of sediment are estimated to reach the ponds, rivers and lakes of our country each year and approximately one billion tons of this sediment is actually carried all the way to the ocean. Approximately 10 percent of this amount is contributed by erosion from land undergoing highway construction or land development (4). Although these latter quantities may appear to be small compared to the total, they could represent more than one-half of the sediment load carried by many streams draining small subwatersheds undergoing development (5).

Sediment yields in streams flowing from already urbanized drainage basins vary from approximately 200 to 500 tons per square mile per year. In contrast, areas undergoing urbanization often have a sediment yield of from 1,000 to 100,000 tons (6). It is easy to comprehend the tremendous quantity of sediment reaching our streams and rivers annually since an estimated 3,000 to 4,000 acres of land in the U.S. are currently undergoing development for housing, industrial site and highway construction every day (4). For very small areas, where construction activities have drastically altered or destroyed vegetative cover and the soil mantle, sediment derived from one acre of land may exceed 20,000 to 40,000 times that obtained from adjacent undeveloped farm or woodland in an equivalent period of time.

Deposition tends to occur as the velocity of sediment-transporting streams decreases. Excessive quantities of sediment cause costly damage to water areas and to private and public lands. Obstruction of stream channels and navigable rivers by masses of deposited sediment reduces their hydraulic capacity which, in turn, causes an increase in subsequent flood crests and a consequent increase in flood damages - frequently with attendant personal injuries and deaths.

Sediment fills drainage channels, especially along highways and railroads, and plugs culverts and storm drainage systems thus necessitating frequent and costly maintenance. Municipal and industrial water supply reservoirs lose storage capacity, the usefulness of recreational impoundments is impaired or destroyed, navigable channels must continually be dredged and the cost of filtering muddy water preparatory to domestic or industrial use becomes excessive --- and sometimes exorbitant. The added expenses of water purification in the United States amounts to millions of dollars each year.

The general effect of fine-grained sediments, such as clays, silts and fine sands, in an aquatic environment is to reduce drastically both the kinds and the amounts of organisms present. Sediments alter the existing aquatic environment by screening out sunlight and by changing the rate and the amount of heat radiation. Particles of silt settling on stream and lake bottoms form a blanket which creates a hostile environment for the organisms living there and literally smothers many of them and their eggs. The disastrous effect (upon commercially valuable fin-fish and shell-fish populations) of excessive amounts of silt entering estuarine waters was widely publicized in the case of the Chesapeake Bay following flooding of its main tributary, the Susquehanna River, caused by Hurricane "Agnes" in 1972.

Coarser-grained materials also blanket bottom areas to suppress aquatic life found on and in these areas. Where currents are sufficiently strong to move the bedload, the abrasive action of these materials in motion accelerates channel scour and has an even more severly deleterious effect upon aquatic life. The aesthetic attraction of many streams, lakes and reservoirs used for swimming, boating, fishing and other water-related recreational activities has been seriously impaired, or destroyed, by bank cutting and channel scour caused by, or associated with, higher flood stages induced by sedimentation.

Erosion and Sediment Hazards Associated with Developing Areas

The development process is such that many people may be adversely affected even by development of areas of land of only limited size. Uncontrolled erosion and sediment from these areas often cause considerable economic damage to individuals and to society in general. Surface water pollution (streams, rivers and lakes), channel and reservoir siltation and damage to public facilities, as well as to private property, are some of many examples of problems caused by uncontrolled erosion and sedimentation.

Hazards associated with development include:

1. A large increase in areas exposed to storm runoff and soil erosion.

2. Increased volumes of storm runoff, accelerated soil erosion and sediment yield and higher peak flows caused by:

   a. Removal of existing protective vegetative cover.
   b. Exposure of underlying soil or geologic formations less pervious and/or more erodible than original soil surface.
   c. Reduced capacity of exposed soils to absorb rainfall due to compaction caused by heavy equipment.
   d. Enlarged drainage areas caused by grading operations, diversions and street construction.
   e. Prolonged exposure of unprotected disturbed areas due to scheduling problems and/or delayed construction.
   f. Shortened times of concentration of surface runoff caused by altering steepness, distance and surface roughness and through installation of "improved" storm drainage facilities.
   g. Increased impervious surfaces associated with the construction of streets, buildings, sidewalks and paved driveways and parking lots.

3. Alteration of the groundwater regime that may adversely affect drainage systems, slope stability and survival of existing and/or newly established vegetation.

4. Creation of exposures facing south and west that may hinder plant growth due to adverse temperature and moisture conditions.

5. Exposure of subsurface materials that are rocky, acid, droughty or otherwise unfavorable to the establishment of vegetation.

6. Adverse alteration of surface runoff patterns by construction and development.

Principles of Reducing Erosion and Sedimentation from Developing Areas

The principles of reducing erosion and sedimentation from developing areas are:

1. Plan the development to fit the particular topography, soils, waterways and natural vegetation at a site.

Initially, this is best achieved through adoption of a general land use plan based upon a comprehensive inventory of soil, water and related resources.

Slope length and gradient are key elements in determining the volume and velocity of the runoff and its associated erosion. As both slope length and steepness increase, the rate of runoff increases and the potential for erosion is magnified. Where possible, steep slopes should be left undisturbed. By limiting the length and steepness of the designed slopes,

runoff volumes and velocities can be reduced and erosion hazards minimized.

Soils which contain a high proportion of silt and very fine sand are generally the most erodible. The erodibility of these soils is decreased as the percentage of clay or organic matter content increases. Well-drained and well-graded gravel-sand mixtures with little silt are the least erodible soils. By reducing the length and steepness of a given slope, even a highly erodible soil may show little evidence of erosion. Long steep slopes should be broken by benching, terracing or constructing diversion structures.

The nearly level area adjacent to either side of the channel of streams is known as the floodplain. Floodplains are important because they store excess runoff temporarily, thus helping to avoid erosion and flooding problems further downstream. Because of this, floodplains should be preserved in their natural state. Construction and filling activities should be excluded from these areas.

The natural vegetative cover is extremely important in controlling erosion since it: (a) shields the soil surface from the impact of falling rain; (b) increases infiltration of water into the soil and (c) reduces the velocity of the runoff water; (d) holds soil particles in place as well as filters surface runoff.

<u>2. Expose the smallest practical area of land for the shortest possible time.</u>

When earth changes are required and the natural vegetation is removed, keep the area and the duration of exposure to a minimum. Plan the phases or stages of development so that only the areas which are actively being developed are exposed. All other areas should have a good cover of temporary or permanent vegetation or mulch. Grading should be completed as soon as possible after it is begun. Then immediately after grading is complete, permanent vegetative cover should be established in the area. As cut slopes are made and as fill slopes are brought up to grade these areas should be revegetated as the work progresses. This is known as staged seeding. Minimizing grading of large or critical areas during the season of maximum erosion potential (May 1 through September 30) reduces the risk of erosion (7).

After the best decision has been made as to land use, and the development process begins, effective erosion control and sediment reduction depends upon careful site planning, judicious selection of conservation practices, adequate design, accurate installation in a timely fashion and sufficient maintenance to insure the intended results.

<u>3. Apply "Soil Erosion" control practices as a first line of defense against on-site damage.</u>

This third principle relates to using practices that control erosion on a site to prevent excessive sediment from being produced. Keep soil covered as much as possible with temporary or permanent vegetation or with various

mulch materials. Special grading methods such as roughening a slope on the contour or tracking with a cleated dozer may be used. Other practices include diversion structures to divert surface runoff from exposed soils and grade stabilization structures to control surface water. "Gross" erosion in the form of gullies must be prevented by these water control devices. Lesser types of erosion such as sheet and rill erosion should be prevented, but often scheduling or the large number of practices required makes this impractical. However, when erosion is not adequately controlled sediment control is more difficult and expensive.

4. Apply "Sediment Control" practices as a perimeter protection to prevent off-site damage.

This principle relates to using practices that control sediment once it is produced and preventing it from getting off-site. Diversion ditches, sediment traps, vegetative filters and sediment basins are examples of practices to control sediment. Vegetative and structural sediment control measures can be classified as either temporary or permanent depending on whether or not they will remain in use after development is complete. Generally, sediment can be retained by two methods: (a) filtering runoff as it flows through an area and (b) impound the sediment laden runoff for a period of time so that the soil particles settle out. The best way to control sediment, however, is to prevent erosion as discussed in the third principle.

5. Implement a thorough maintenance and follow-up operation.

This fifth principle is very vital to the success of the four other principles. A site cannot be effectively controlled without thorough, periodic checks of the erosion and sediment control practices. These practices must be maintained just as construction equipment must be maintained and materials checked and inventoried. An example of applying this principle would be to start a routine "end of day check" to make sure that all control practices are working properly.

Usually, these five principles are integrated into a system of vegetative measures and structural measures along with management techniques to develop a plan to prevent erosion and sediment control. In most cases, a combination of limited grading, limited time of exposure and a judicious selection of erosion control practices and sediment trapping facilities will prove to be the most practical method of controlling erosion and the associated production and transport of sediment.

Standards and Specifications for Erosion and Sediment Control in Developing Areas

The purpose of these Standards and Specifications is to establish uniform criteria for the design, review, approval, installation and maintenance of erosion control and sediment reduction practices on land undergoing grading, construction or development. Those responsible for selection and design or for review and approval of these practices should evaluate the conditions

existing at the specific site and determine if the minimum criteria contained herein are adequate or if more stringent criteria should be employed.

It is intended that these Standards and Specifications will be used as the approved erosion and sediment control practices for the State of Maryland. However, innovative methods are encouraged provided that they are approved by the appropriate sediment control approving agency. It is suggested that the approving agency forward copies of any innovative ideas to the state office of the Soil Conservation Service and Water Resources Administration for the purpose of evaluation and dissemination.

These Standards and Specifications were written to be generally applicable to all development and construction sites in Maryland. However, there may be many specific problems or sites not appropriately covered by these standards. It is intended that modifications to these Standards and Specifications may be made by the approving sediment control agency in order to improve or update them. The agency may also determine the applicability of a given practice in a specific situation.

Several of these Standards are new and somewhat experimental in nature but represent a significant improvement over the "nothing" that they replaced. After a trial period any comments on these practices should be presented to the Soil Conservation Service or Water Resources Administration as mentioned above.

These Standards and Specifications have been organized into four general areas (allowing space in the numbering system for future additions):

I. Temporary Structural Practices
II. Permanent Structural Practices
III. Vegetative Practices (Temporary and Permanent)
IV. Special Practices

Structural practices are constructed for the purpose of controlling the flow of water, preventing erosion by flowing water or trapping sediment. Vegetative practices are concerned with covering the soil surface with growing vegetation, usually with the help of such things as soil amendments or mulches, in order to stabilize the soil surface and prevent erosion.

Temporary practices are those used for relatively short periods of time - three months limit on Straw Bale Dike up to 36 month limit on Sediment Basin - to accomplish erosion or sediment control during some stage of construction. Requirements for temporary practices in the Standards and Specifications have been "trimmed down" in order for them to accomplish their intended purpose with a minimum of cost. These practices must not be used for longer than the periods of time prescribed. Also, individual designs are not required for temporary structural practices in order to economize as much as possible on the designer's time. Two temporary practices, Straw Bale Dike and Sediment Trap, are "stop gap" measures snd should be used only when nothing else will work. Permanent practices are to be used for permanent features, for an indefinite period of time or when the temporary practices are not adequate.

The Standards and Specifications are such that the permanent practices will accomplish their intended function with a minimum of maintenance over long periods of time, such as an underground storm drainage system would. Permanent practices may also be used on a temporary basis if necessary. Permanent practices require individual designs in order to fit the practices to individual situations.

This publication has been compiled in such a manner to facilitate its use by various users. Standard drawings and construction specifications have been printed together so they could be easily copied and used by field personnel. Structural practice appendices, usually frequently referred to by the designer have been placed immediately behind the appropriate Standard and Specifications but may be removed and placed in a "working handbook" so as not to have to thumb through the remainder of the publication.

The Sediment Control Plan

The required sediment control plan is a plan for controlling erosion and sediment during construction in compliance with the laws, ordinances and these Standards and Specifications. This plan shall be a part of the total site development plan and prescribes all the steps necessary including scheduling to assure erosion and sediment control during all phases of construction including final stabilization.

Planning for sediment control should begin with the concept plan and its preparation. Such features as soils and topography should be considered for the concept plan as well as any requirements for sediment control or storm water management. Technical assistance on erosion and sediment control, soils information and many other related subjects are available through the Soil Conservation District office for each county and for the District of Columbia. This assistance should first be sought in the pre-concept-plan stage.

Planning for sediment control should also begin with first-hand knowledge of the site by the designer. The plan shall be based on a sufficiently accurate topographic map that reflects the existing topography and site conditions. Adjacent off-site areas affecting the site or affected by the site and its development shall be shown on the plans in sufficient detail to accomplish the need. Examples of this would be areas draining onto the site or areas where storm runoff leaves the site and travels to a stream or public storm drainage system.

The sediment control plan will consist of the best selection of erosion control practices and sediment trapping facilities in conjunction with an appropriate schedule in order to accomplish an adequate level of control. Particular attention must be given to concentrated flows of water, either to prevent its occurrence or to provide conveyance devices according to the Standards and Specifications to prevent "major" or "gross" type erosion. Sediment trapping devices will usually be required at all points of egress of sediment laden water. The plan must include permanent structures for conveying storm runoff, final site stabilization, removal of temporary sediment

control features such as sediment basins and finally, stabilization of the sites where temporary features were removed. Plans showing improvements or construction to be done outside the property line for the site will generally not be approved unless the plan is accompanied by an appropriate legal easement for the area in which the work is to be done

The standardizing of sediment control plans makes them easier to study and quicker to review. The use of standard symbols helps to standardize plans and these are shown on the Standard Drawings and also summarized on the List of Standard Symbols. These symbols were developed to facilitate plan review and to be easy to apply to the drawings by drafting or by the use of standard "stick-on" materials. The symbols should be bold and tend to "stand out" on the plans.

There are many scales that have been used for plans, with some being easy to review and others being very difficult to review. Therefore, unless otherwise approved one of the following scales shall be used for the detailed sediment control plans for urban development sites; 1" = 20', 1" = 30', 1" = 40', or 1" = 50'. The contour interval for these plans shall be two feet or closer. Other scales or contour intervals are used for certain other types of plans depending on such things as the approving agency, type of plan and area of the State. For example, strip mine plans are drawn to scales such as 1" = 200' or 1" = 500' with contour intervals of 5 to 20 feet. However, prior to the use of these scales or contour intervals, approval should be obtained from the local Soil Conservation District and other approving agencies. Some agencies have developed written guidelines for developing and reviewing sediment control plans. These guidelines can be very helpful to designers and even though they are general in nature they greatly facilitate the planning, review and approval of sediment plans. Some examples of these guidelines are in the Appendix including requirements for plans and a plan reviewer's check list. They are shown for information only and are not the complete checklist or requirements for any specific agency.

Training

The Water Resources Administration has developed a 13 lesson audiovisual training program for Erosion and Sediment Control Specialists. Each lesson is composed of from one to three cassettes containing 150 to 450 frames and supporting text material. Portable teaching machines in which the visual image is projected on a small television-like screen are used for individual instruction or can be projected forward to a large screen for group instruction. This training is normally scheduled through the local Soil Conservation Districts. The following is a list of the 13 lesson audiovisual training program: (1) Goals, Objectives and Principles of Erosion and Sediment Control, (2) Soils, (3) Rainfall-Runoff Relationship, (4) Erosion and Sedimentation, (5) Plant Materials, (6) Control of Runoff During Construction, (7) Vegetative Soil Stabilization, (8) Waterway Erosion Control, (9) Temporary Soil Stabilization, (10) Control of Sediment Generated on Construction Sites, (11) Erosion and Sediment Control Planning, (12) Wooded Site Development, and (13) Foreman-Inspector Responsibilities.

For the Future

It is expected that at some future time this assembly of standards and specifications will be but one chapter or section of a complete handbook providing guidance to all aspects of the sediment control program in Maryland. Possibilities for other sections are:

1. Extent of erosion and sediment problems in Maryland.

2. Applicable state and local legislation and regulations.

3. Using task force approach in developing, evaluating and improving the sediment control program.

4. Information and education program.

5. Operating procedures.

6. Criteria for developing the sediment control plan.
   a. Universal Soil Loss Equation
   b. Storm Water Management

7. Criteria for reviewing the sediment control plan.

8. Storm Water Management.

9. Inspection and enforcement.

10. Training

11. Evaluation

12. Appendix

    a. Research findings
    b. Research needs
    c. Bibliography
    d. Practical examples of key items
    e. Sources of vegetative and construction materials used in erosion and sediment control.

LIST OF STANDARD SYMBOLS

Diversion Dike..	DD 2/
Interceptor Dike..	ID 2/
Perimeter Dike..	PD 2/
Straw Bale Dike...	SBD 2/
Interceptor Swale...	IS
Perimeter Swale...	PS
Stabilized Construction Entrance................................	SCE
Stone Outlet Structure..	SOS L=
Grade Stabilization Structure	
Chute or Flume (Example for size group A and six foot bottom width)...............	GSS-1 A-6
Rigid Pipe Slope Drain (Example for 12" diameter pipe)..................	GSS-2 PSD-12
Flexible Pipe Slope Drain (Example for 18" diameter pipe)...............	GSS-3 PSD-18
Diversion...	
Grassed Waterway..	GW
Level Spreader..	L=
Subsurface Drain..	

Notes:
1. Arrows point downslope or to the outlet.
2. Dike and diversion symbols, shall have a cross mark to clearly show where the structure begins and ends.

SECTION I

STANDARDS AND SPECIFICATIONS

FOR

TEMPORARY STRUCTURAL PRACTICES

STANDARD AND SPECIFICATIONS

FOR

DIVERSION DIKE

Definition

A temporary ridge of compacted soil immediately above cut or fill slopes and constructed with sufficient grade to provide drainage.

Purpose

The purpose of a diversion dike is to intercept storm runoff from small upland areas and divert it from exposed slopes to an acceptable outlet.

Conditions Where Practice Applies

The diversion dike is used for the period of construction at the top of newly constructed slopes to prevent excessive erosion until permanent drainage features are installed and/or slopes are stabilized.

Design Criteria

A design is not required for diversion dikes. The following criteria shall be used.

Drainage area - less than 5 acres (for larger drainage areas see Standard and Specifications for Diversion).

Top width - 2 feet minimum
Height (compacted fill) - 18 inches minimum height measured from the existing ground at the upslope toe to top of the dike.

Side slopes - 2:1 or flatter
Grade - dependent upon topography, but must have positive drainage (sufficient grade to drain) to an adequate outlet.
Stabilization - Where slope of channel (flow area) is:

0%-5% - stabilization may be required by the designer according to the needs of the site.

Over 5% - stabilization shall be required.

Stabilization shall be: (1) in accordance with Standard and Specifications for Diversion; or (2) by lining the flow area with stone that meets MSHA size No. 2 or AASHTO M43 size No. 2 or 24 in a layer at least 3 inches in thickness and pressed into the soil. The lining shall

extend up the upslope side of the dike a height of at least 8 inches measured vertically from the upslope toe and shall extend at least 7 feet upslope from the upslope toe. (8,9)

See Standard Drawing DD-1 for details.

Outlet

A. Diverted runoff from a protected or stabilized area shall outlet directly to an undisturbed stabilized area or into a level spreader or grade stabilization structure.

B. Diverted runoff from a disturbed or exposed upland area shall be conveyed to a sediment trapping device such as a sediment trap or a sediment basin or to an area protected by any of these practices.

Construction Specifications.

1. All dikes shall be machine compacted.

2. All diversion dikes shall have positive drainage to an outlet.

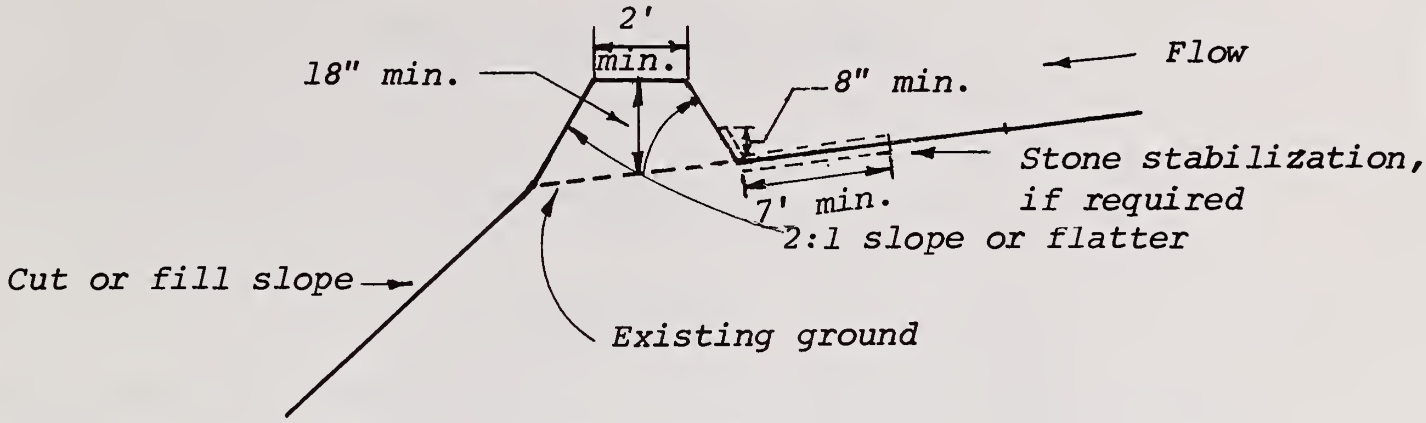
3. A. Diverted runoff from a protected or stabilized area shall outlet directly to an undisturbed stabilized area or into a level spreader or grade stabilization structure.

   B. Diverted runoff from a disturbed or exposed upland area shall be conveyed to a sediment trapping device such as a sediment trap or a sediment basin or to an area protected by any of these practices.

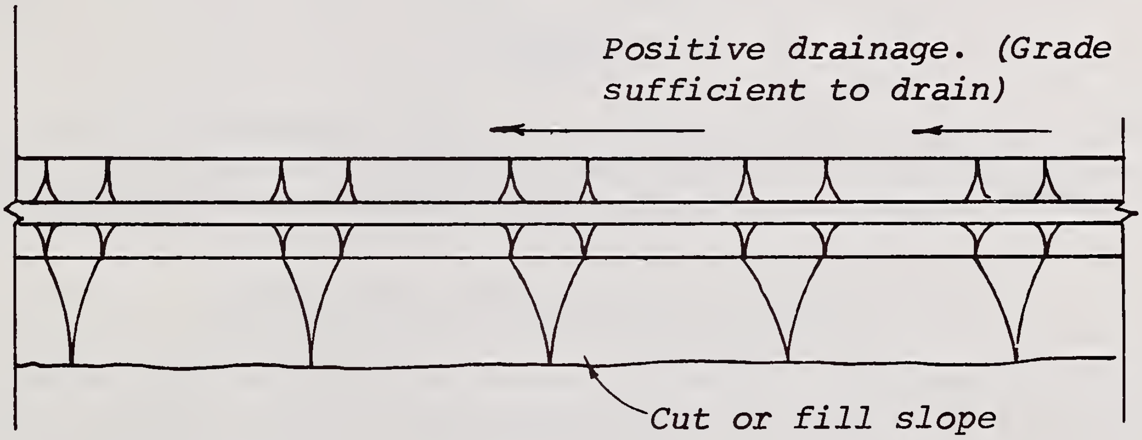
4. Stabilization, as specified by the plans, shall be: (1) in accordance with Standard and Specifications for Diversion, and the area to be stabilized shall be the channel (flow area); or (2) the flow area shall be lined with stone that meets MSHA size No. 2 or AASHTO M43 size No. 2 or 24 which is placed in a 3 inch thick layer and pressed into the soil. The area covered by the stone shall be as shown on Standard Drawing DD-1.

5. Periodic inspection and required maintenance shall be provided.

DIVERSION DIKE*



CROSS SECTION



PLAN VIEW

Construction Specifications.

1. All dikes shall be machine compacted.
2. All diversion dikes shall have positive drainage to an outlet.
3. A. Diverted runoff from a protected or stabilized area shall outlet directly to an undisturbed stabilized area or into a level spreader or grade stabilization structure.
   B. Diverted runoff from a disturbed or exposed upland area shall be conveyed to a sediment trapping device such as a sediment trap or a sediment basin or to an area protected by any of these practices.
4. Stabilization, as specified by the plans, shall be: (1) in accordance with Standard and Specifications for Grassed Waterway, and the area to be stabilized shall be the channel (flow area); or (2) the flow area shall be lined with stone that meets MSHA size No. 2 or AASHTO M43 size No. 2 or 24 which is placed in a 3 inch thick layer and pressed into the soil. The area covered by the stone shall be as shown on the drawing above.
5. Periodic inspection and required maintenance shall be provided.

Standard Symbol ⊢— DD —→

* Drainage area less than 5 acres

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE College Park, Md.	DIVERSION DIKE	Standard Drawing DD-1

STANDARD AND SPECIFICATIONS

FOR

INTERCEPTOR DIKE

Definition

A temporary ridge of compacted soil, located across disturbed areas or rights-of-way.

Purpose

The purpose of an interceptor dike is to shorten the length of exposed slopes, thereby reducing the potential for erosion, by intercepting storm runoff and diverting it to a stabilized outlet or sediment trapping device.

Conditions Where Practice Applies

Interceptor dikes are constructed across disturbed rights-of-way such as for pipe lines and streets or disturbed areas such as graded parking lots or landfills. The dikes shall remain in place until the disturbed areas are permanently stabilized.

Design Criteria

A design is not required for interceptor dikes. The following criteria shall be used:

Drainage area - less than 5 acres (for larger drainage areas see Standard and Specifications for Diversion).

Top Width - 2 feet minimum.

Height - 18 inches minimum height measured from the existing or graded ground at the upslope toe to top of the dike.

Side slopes - 2:1 or flatter (flat enough to allow construction traffic to cross if desired).

Grade - 0.5% to 1.0% and must have positive drainage (sufficient grade to drain) to an acceptable outlet.

Stabilization - not required by this Standard but may be required by the designer according to the needs of the site.

Stabilization, when required, shall be: (1) in accordance with Standard and Specifications for Diversion; or (2) by lining the flow area with stone that meets MSHA size

No. 2 or AASHTO M43 size No. 2 or 24 in a layer at least 3 inches in thickness and pressed into the soil. The lining shall extend up the upslope side of the dike a height of at least 8 inches measured vertically from the upslope toe and shall extend at least 7 feet upslope from the upslope toe. (8,9)

Spacing -

Slope of right-of-way or disturbed areas above dike:	greater than 10%	5-10%	less than 5%
Maximum distance between dikes:	100 feet	200 feet	300 feet

See Standard Drawing ID-1 for details.

Outlet

Interceptor dikes shall have an outlet that functions with a minimum of erosion.

Runoff shall be conveyed to a sediment trapping device such as a sediment trap or sediment basin when either the interceptor dike channel or the drainage area above the dike are not adequately stabilized.

The on-site location may need to be adjusted to meet field conditions in order to utilize the most suitable outlet.

Construction Specifications

1. All dikes shall be machine compacted.

2. All interceptor dikes shall have positive drainage to an outlet.

3. Top width may be wider and side slopes may be flatter if desired to facilitate crossing by construction traffic.

4. Field location should be adjusted as needed to utilize a stabilized safe outlet.

5. Interceptor dikes shall have an outlet that functions with a minimum of erosion. Runoff shall be conveyed to a sediment trapping device such as a sediment trap or sediment basin when either the interceptor dike channel or the drainage area above the dike are not adequately stabilized.

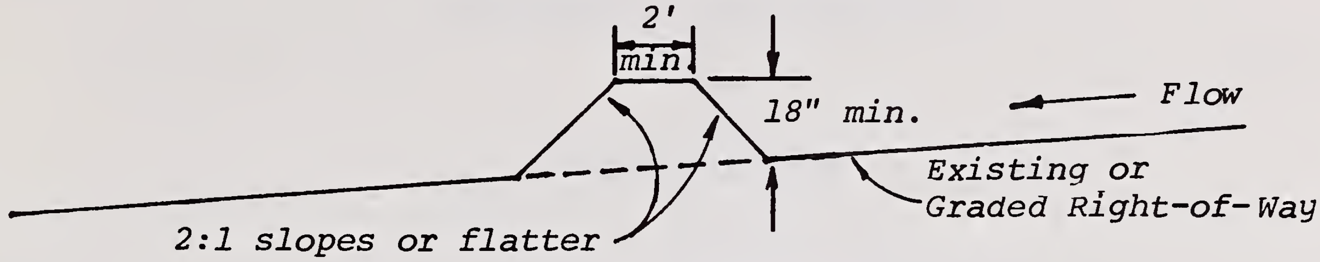
6. Stabilization, as specified by the plans, shall be: (1) in accordance with Standard and Specifications for Diversion, and the area

to be stabilized shall be the channel (flow area); or (2) the flow area shall be lined with stone that meets MSHA size No. 2 or AASHTO M43 size No. 2 or 24 which is placed in a 3 inch thick layer and pressed into the soil. The area covered by the stone shall be as shown on Standard Drawing DD-1.

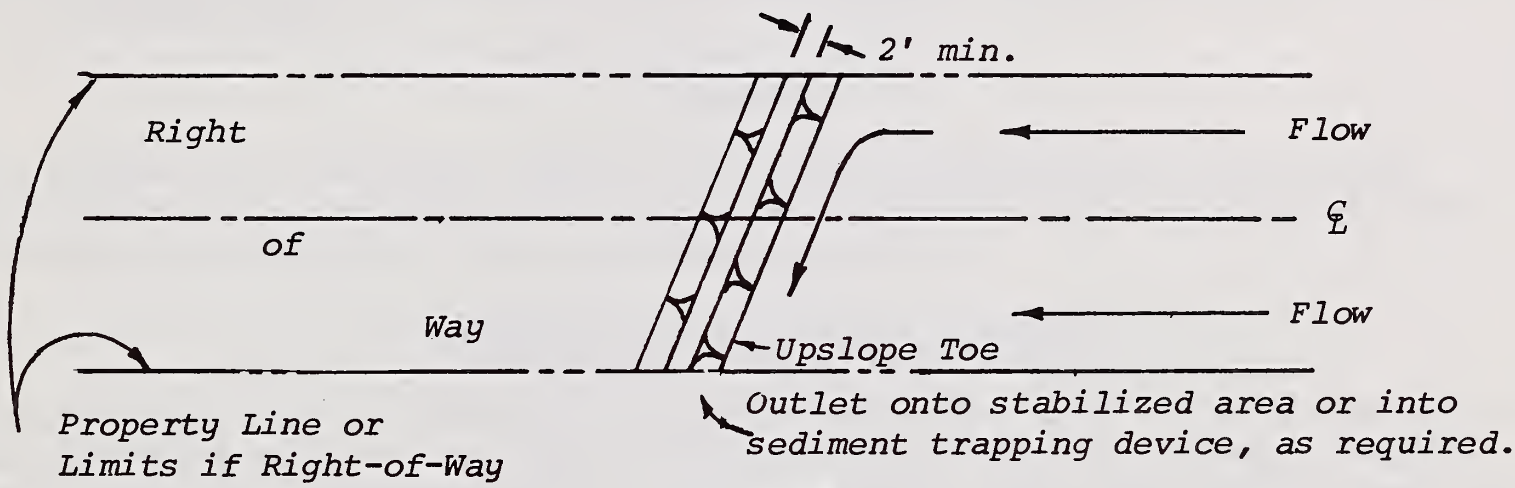
7. Periodic inspection and required maintenance must be provided.

See the following page for the Standard Drawing ID-1.

INTERCEPTOR DIKE*
(not to scale)



CROSS SECTION



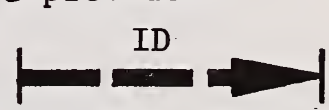
PLAN VIEW

Construction Specifications

1. All dikes shall be machine compacted.
2. All interceptor dikes shall have positive drainage to an outlet.
3. Top width may be wider and side slopes may be flatter if desired to facilitate crossing by construction traffic.
4. Field location should be adjusted as needed to utilize a stabilized safe outlet.
5. Interceptor dikes shall have an outlet that functions with a minimum of erosion. Runoff shall be conveyed to a sediment trapping device such as a sediment trap or sediment basin when either the interceptor dike channel or the drainage area above the dike are not adequately stabilized.
6. Stabilization, as specified by the plans, shall be: (1) in accordance with Standard and Specifications for Grassed Waterway, and the area to be stabilized shall be the channel (flow area); or (2) the flow area shall be lined with stone that meets MSHA size No. 2 or AASHTO size No. 2 or 24 which is placed in a 3 inch thick layer and pressed into the soil. The area covered by the stone shall be as shown on Standard Drawing DD-1.
7. Periodic inspection and required maintenance must be provided.

* Drainage area less than 5 acres.

Standard Symbol



U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE College Park, Md.	INTERCEPTOR DIKE	Standard Drawing ID-1

STANDARD AND SPECIFICATIONS

FOR

PERIMETER DIKE

Definition

A temporary ridge of compacted soil located along the perimeter of the site or disturbed areas.

Purpose

The purpose of a perimeter dike is to prevent offsite storm runoff from entering the disturbed area and to prevent sediment laden storm runoff from leaving the construction site or disturbed area.

Conditions Where Practice Applies

The perimeter dike is used for the period of construction at the perimeter of the disturbed area to transport sediment laden water to a sediment trapping device such as a sediment trap or sediment basin. This dike shall remain in place until the disturbed area is permanently stabilized. The storm runoff prevented from entering the disturbed area by the perimeter dike shall be adequately handled to prevent damage due to flooding or erosion to adjacent property.

Design Criteria

The perimeter dike shall not be constructed outside the property lines without obtaining legal easements from affected adjacent property owners. A design is not required for perimeter dikes. The following criteria shall be used:

Drainage Area - less than 5 acres (for larger drainage areas see Standard and Specifications for Diversion).

Top Width - 2 feet minimum

Height - 18 inches minimum height measured from the existing or graded ground at the upslope toe to top of the dike.

Side slopes - 2:1 or flatter (flat enough to allow construction traffic to cross if desired).

Grade - dependent upon topography, but shall have positive drainage (sufficient grade to drain) to an adequate outlet.

Stabilization - Where slope of the channel (flow area) is:

0-5% - Stabilization may be required by the designer according to the needs of the site.

Over 5% - Stabilization shall be required.

Stabilization - Shall be: (1) in accordance with Standard and Specifications for Diversion, and the area to be stabilized shall be the channel (flow area); or (2) the flow area shall be lined with stone that meets MSHA size No. 2 or AASHTO M43 size No. 2 or 24 which is placed in a 3 inch thick layer and pressed into the soil. The area covered by the stone shall be as shown on Standard Drawing DD-1.

See Standard Drawing PD-1 for details.

Outlet

1. Diverted runoff from a protected or stabilized upland area shall outlet directly onto an undisturbed stabilized area or into a level spreader or grade stabilization structure.

2. Diverted runoff from a disturbed or exposed upland area shall be conveyed to a sediment trapping device such as a sediment trap or a sediment basin or to an area protected by any of these practices.

Construction Specifications

1. All dikes shall be machine compacted.

2. All perimeter dikes shall have positive drainage to an outlet.

3. A. Diverted runoff from a protected or stabilized upland area shall outlet directly onto an undisturbed stabilized area or into a level spreader or grade stabilization structure.

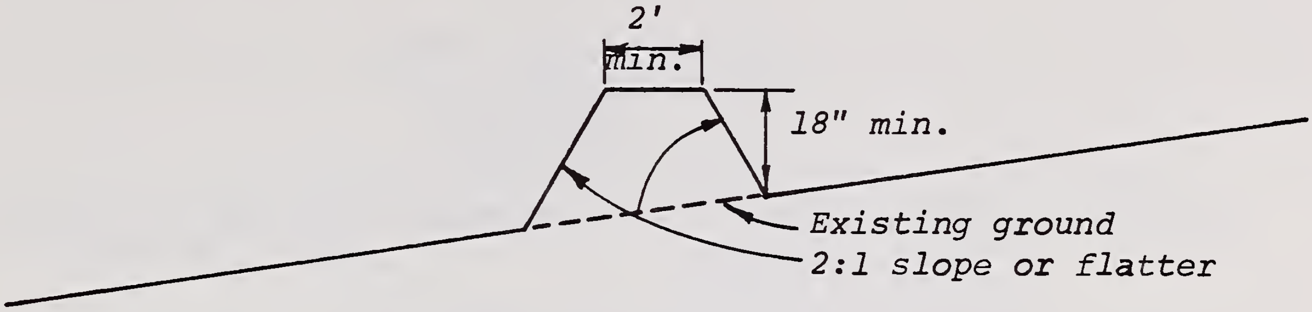
   B. Diverted runoff from a disturbed or exposed upland area shall be conveyed to a sediment trapping device such as sediment trap or a sediment basin or to an area protected by any of these practices.

4. Stabilization, as specified by the plans, shall be: (1) in accordance with Standard and Specifications for Diversion, and the minimum area to be stabilized shall be the channel (flow area); or (2) the flow area shall be lined with stone that meets MSHA size No. 2 or AASHTO M43 size No. 2 or 24 which is placed in a 3 inch thick layer and pressed into the soil. The area covered by the stone shall be as shown on Standard Drawing DD-1.

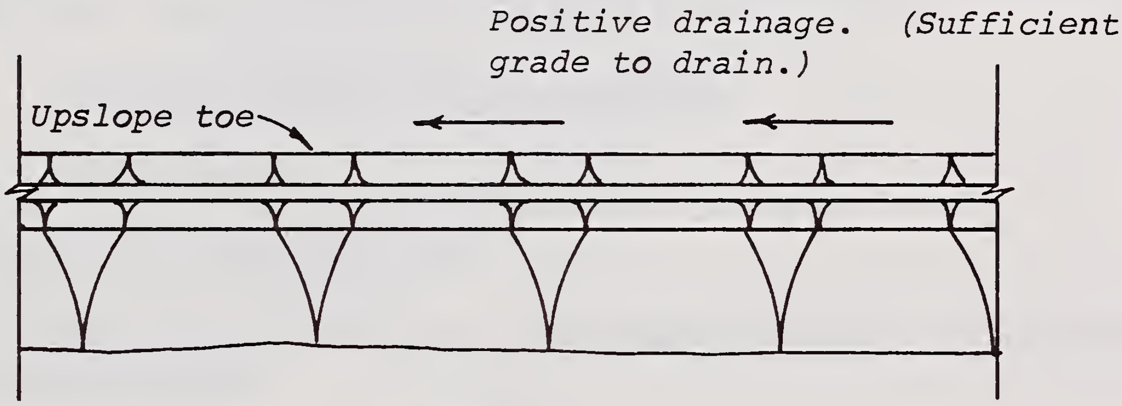
5. Periodic inspection and required maintenance shall be provided.

PERIMETER DIKE*

(not to scale)



CROSS SECTION

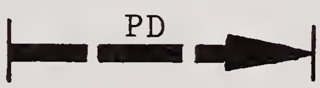


PLAN VIEW

Construction Specifications

1. All dikes shall be machine compacted.
2. All perimeter dikes shall have positive drainage to an outlet.
3. A. Diverted runoff from a protected or stabilized upland area shall outlet directly onto an undisturbed stabilized area or into a level spreader or grade stabilization structure.

   B. Diverted runoff from a disturbed or exposed upland area shall be conveyed to a sediment trapping device such as sediment trap or a sediment basin or to an area protected by any of these practices.
4. Stabilization, when required, shall be done in accordance with Standard and Specifications for Grassed Waterway. The minimum area to be stabilized shall be the channel flow area.
5. Periodic inspection and required maintenance shall be provided.

Standard Symbol 

* Drainage area less than 5 acres

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE College Park, Md.	PERIMETER DIKE	Standard Drawing PD-1

STANDARD AND SPECIFICATIONS

FOR

STRAW BALE DIKE

Definition

A temporary barrier with a life expectancy of 3 months or less, installed across or at the toe of a slope.

Purpose

The purpose of a straw bale dike is to intercept and detain small amounts of sediment from unprotected areas of limited extent.

Conditions Where Practice Applies

The straw bale dike is used where:

1. No other practice is feasible, and

2. There is no concentration of water in a channel or other drainageway above the barrier, and

3. Erosion would occur in the form of sheet and rill erosion, and

4. Contributing drainage area is less than 1/2 acre and the length of slope above the dike is less than 100 feet. The practice may also be used for a lone single-family lot if the slope is less than 15%. The contributing drainage area in this instance shall be less than 1 acre and the length of slope above the dike shall be less than 200 feet.

Design Criteria

A design is not required. All bales shall be placed on the contour and shall be either wire bound or nylon string tied. See Standard Drawing SBD-1 for details.

Construction Specifications

1. Bales shall be placed in a row with ends tightly abutting the adjacent bales.

2. Each bale shall be embedded in the soil a minimum of 4".

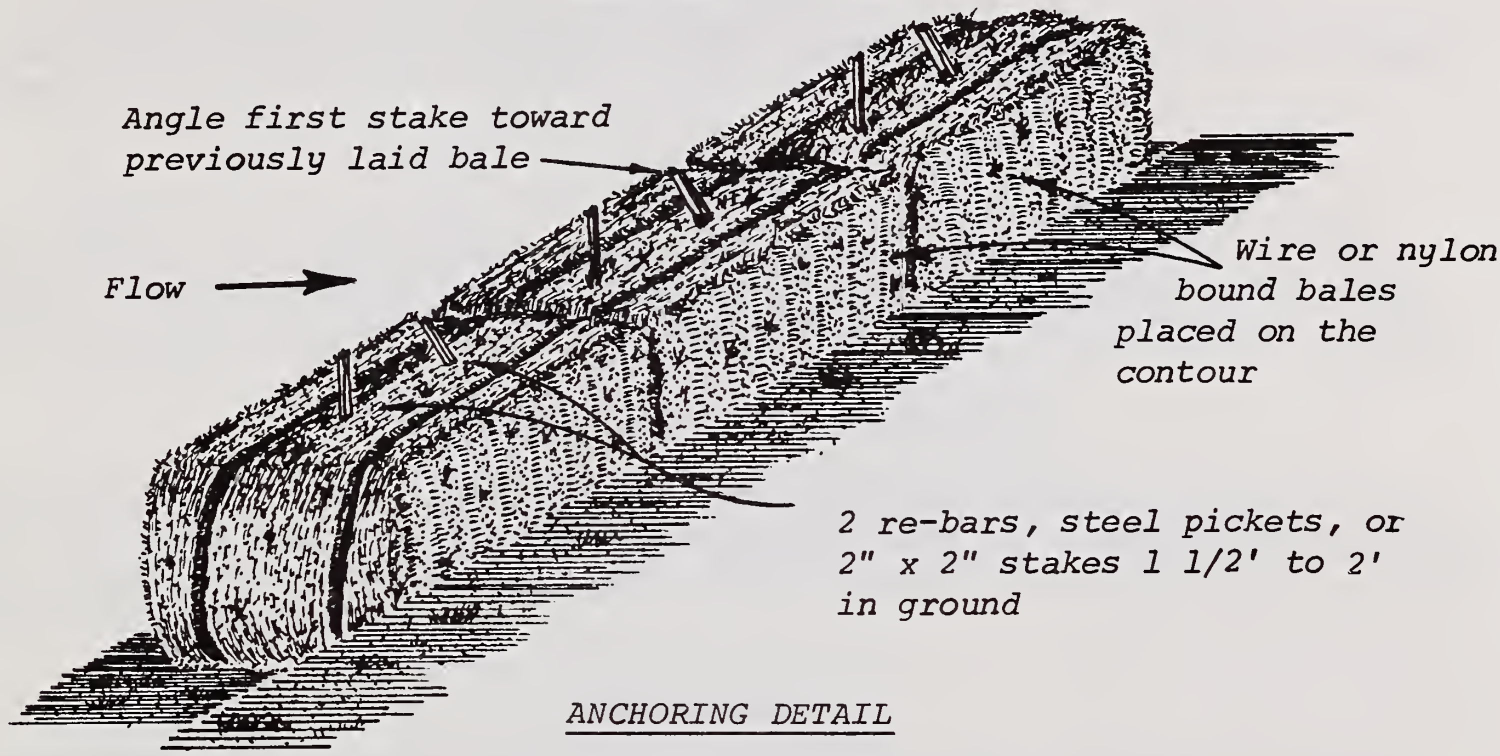
3. Bales shall be securely anchored in place by stakes or re-bars driven through the bales. The first stake in each bale shall be driven toward previously laid bale to force bales together.

4. Inspection shall be frequent and repair or replacement shall be made promptly as needed.

5. Bales shall be removed when they have served their usefullness so as not to block or impede storm flow or drainage.

STRAW BALE DIKE*

EMBEDDING DETAIL



ANCHORING DETAIL

Construction Specifications

1. Bales shall be placed in a row with ends tightly abutting the adjacent bales.
2. Each bale shall be embedded in the soil a minimum of 4".
3. Bales shall be securely anchored in place by stakes or re-bars driven through the bales. The first stake in each bale shall be angled toward previously laid bale to force bales together.
4. Inspection shall be frequent and repair or replacement shall be made promptly as needed.
5. Bales shall be removed when they have served their usefulness so as not to block or impede storm flow or drainage.

Standard Symbol ▬ ▬ SBD ▬ ▬

* Drainage area less than 1/2 acre.

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE College Park, Md.	STRAW BALE DIKE	Standard Drawing SBD-1

STANDARD AND SPECIFICATIONS

FOR

INTERCEPTOR SWALE

Definition

A temporary excavated drainageway located across disturbed areas or rights-of-way.

Purpose

The purpose of an interceptor swale is to shorten the length of exposed slopes, thereby reducing the potential for erosion, by intercepting storm runoff and diverting it to a stabilized outlet or sediment trapping device.

Conditions Where Practice Applies

Interceptor swales are constructed across disturbed rights-of-way such as for pipe lines and streets or disturbed areas such as graded parking lots or land fills. The swale shall remain in place until the disturbed areas are permanently stabilized.

Design Criteria

A design is not required for interceptor swales. The following criteria shall be used:

Drainage area - less than 5 acres (for larger drainage areas see Standard and Specifications for Grassed Waterway).

Bottom width - 7 feet minimum and the bottom shall be level.

Depth - 1 foot minimum

Side slopes - 2:1 or flatter (flat enough to allow construction traffic to cross if desired).

Grade - 1% to 3%; must have positive drainage (sufficient grade to drain) to an adequate outlet.

Stabilization - not required by this Standard but may be required by the designer according to the needs of the site. Stabilization shall be: (1) in accordance with the Standard & Specifications for Grassed Waterway; or (2) by lining the flow area with stone that meets MSHA size No. 2 or AASHTO M43 size No. 2 or 24 in a layer at least 3 inches in thickness and pressed into the soil. The lining shall extend across the bottom and up both

sides of the channel a height of at least 8 inches vertically above the bottom. (8,9)

Traffic crossings - At all points where several or more vehicle crossings per day will be made, the swale shall be stabilized according to No. 2 except the stone lining shall be at least 6 inches in thickness for the full width of the traffic crossing roadway.

Spacing -

Slope of right-of-way or disturbed area	greater than 10%	5 - 10%	less than 5%
Maximum distance between swales	100 feet	200 feet	300 feet

Outlet

An interceptor swale shall have an outlet that functions with a minimum of erosion.

Runoff shall be conveyed to a sediment trapping device such as a sediment trap or sediment basin.

The on-site location may need to be adjusted to meet field conditions in order to utilize the most suitable outlet.

CONSTRUCTION SPECIFICATIONS

1. All trees, brush, stumps, obstructions, and other objectionable material shall be removed and disposed of so as not to interfere with the proper functioning of the swale.

2. The swale shall be excavated and/or shaped to line, grade, and cross section as required to meet the criteria specified herein and be free of bank projections or other irregularities which will impede normal flow.

3. Fills shall be compacted as needed to prevent unequal settlement that would cause damage in the completed swale.

4. All earth removed and not needed in construction shall be spread or disposed of so that it will not interfere with the functioning of the swale.

5. Interceptor swales shall have a minimum grade of one percent and the bottom shall be level.

6. An interceptor swale shall have an outlet that functions with a minimum of erosion.

7. Runoff shall be conveyed to a sediment trapping device such as a sediment trap or sediment basin.

8. The on-site location may need to be adjusted to meet field conditions in order to utilize the most suitable outlet.

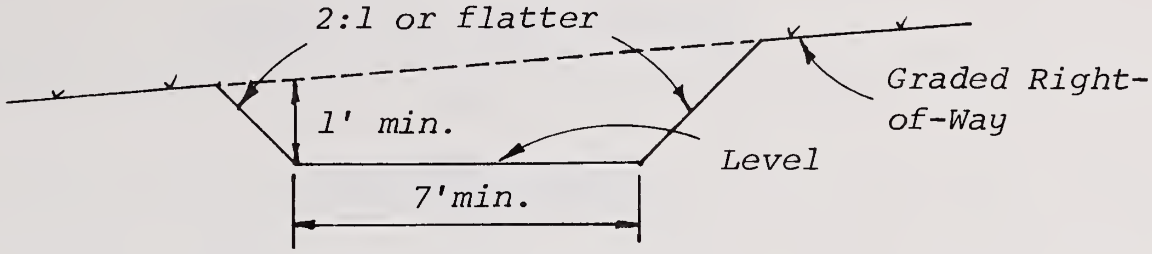
9. Stabilization shall be: (1) in accordance with the Standard & Specifications for Grassed Waterway; or (2) by lining the flow area with stone that meets MSHA size No. 2 or AASHTO M43 size No. 2 or 24 in a layer at least 3 inches in thickness and pressed into the soil. The lining shall extend across the bottom and up both sides of the channel a height of at least 8 inches vertically above the bottom.

10. Periodic inspection and required maintenance shall be provided.

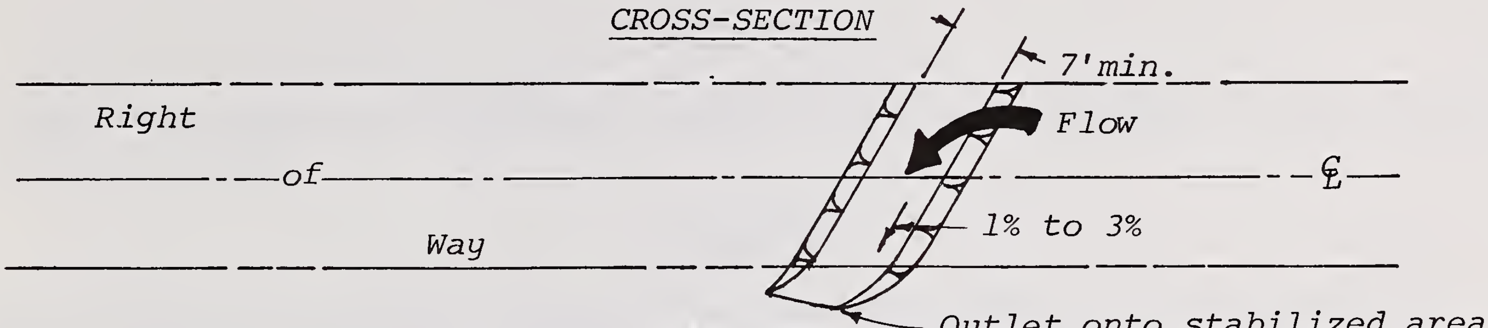
See the following page for Standard Drawing IS-1.

INTERCEPTOR SWALE

(not to scale)



CROSS-SECTION



PLAN VIEW

Construction Specifications

1. All trees, brush, stumps, obstructions, and other objectionable material shall be removed and disposed of so as not to interfere with the proper functioning of the swale.
2. The swale shall be excavated or shaped to line, grade, and cross section as required to meet the criteria specified herein and be free of bank projections or other irregularities which will impede normal flow.
3. Fills shall be compacted as needed to prevent unequal settlement that would cause damage in the complete swale.
4. All earth removed and not needed in construction shall be spread or disposed of so that it will not interfere with the functioning of the swale.
5. Interceptor swales shall have a minimum grade of one percent and the bottom shall be level.
6. An interceptor swale shall have an outlet that functions with a minimum of erosion.
7. Runoff shall be conveyed to a sediment trapping device such as a sediment trap or sediment basin.
8. The on-site location may need to be adjusted to meet field conditions in order to utilize the most suitable outlet.
9. Stabilization shall be: (1) in accordance with the Standard and Specifications for Grassed Waterway; or (2) by lining the flow area with stone that meets MSHA size No. 2 or AASHTO M43 size No. 2 or 24 in a layer at least 3 inches in thickness and pressed into the soil. The lining shall extend across the bottom and up both sides of the channel a height of at least 8 inches vertically above the bottom.
10. Periodic inspection and required maintenance shall be provided.

Standard Symbol 

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE College Park, Md.	INTERCEPTOR SWALE	Standard Drawing IS-1

STANDARD AND SPECIFICATIONS

FOR

PERIMETER SWALE

Definition

A temporary excavated drainageway located along the perimeter of the site or disturbed areas.

Purpose

The purpose of a perimeter swale is to prevent offsite storm runoff from entering the disturbed area and to prevent sediment laden storm runoff from leaving the construction site or disturbed area.

Conditions Where Practice Applies

The perimeter swale is used for the period of construction at the perimeter of the disturbed area to transport sediment laden water to a sediment trapping device such as a sediment trap or sediment basin. This swale shall remain in place until the disturbed area is permanently stabilized. The perimeter swale also is used to prevent storm runoff from entering the disturbed area. This runoff shall be adequately handled to prevent damage due to flooding or erosion to adjacent property.

Design Criteria

The perimeter swale shall not be constructed outside the property lines without obtaining legal easements from affected adjacent property owners. A design is not required for perimeter swale. The following criteria shall be used:

Drainage Area - less than 5 acres (for larger drainage areas, see Standard and Specifications for Diversion or Grassed Waterway).

Bottom Width - 7 feet minimum and the bottom shall be level.

Depth - 1 foot minimum

Side Slope - 2:1 or flatter (flat enough to allow construction traffic to cross if desired).

Grade - dependent upon topography, but shall have a minimum grade of one percent to an adequate outlet.

Stabilization - where slope of the channel (flow area) is:

1-5% - Stabilization may be required by the designer according to the needs of the site.

Over 5% - Stabilization shall be required.

Stabilization shall be: (1) in accordance with the Standard & Specifications for Grassed Waterway; or (2) by lining the flow area with stone that meets MSHA size No. 2 or AASHTO M43 size No. 2 or 24 in a layer at least 3 inches in thickness and pressed into the soil. The lining shall extend across the bottom and up both sides of the channel a height of at least 8 inches vertically above the bottom.

Traffic crossings - At all points where several vehicle crossings per day will be made, the swale shall be stabilized according to No. 2 above, except the stone lining shall be at least 6 inches in thickness for the full width of the traffic crossing roadway.

Outlet

1. Diverted runoff from a protected or stabilized upland area shall outlet directly onto an undisturbed stabilized area, level spreader or into a grade stabilization structure.

2. Diverted runoff from a disturbed or exposed upland area shall be conveyed to a sediment trapping device such as a sediment trap or a sediment basin or within an area protected by any of these practices.

CONSTRUCTION SPECIFICATIONS

1. All trees, brush, stumps, obstructions, and other objectionable material shall be removed and disposed of so as not to interfere with the proper functioning of the swale.

2. The swale shall be excavated and/or shaped to line, grade, and cross section as required to meet the criteria specified herein and be free of bank projections or other irregularities which will impede normal flow.

3. Fills shall be compacted as needed to prevent unequal settlement that would cause damage in the completed swale.

4. All earth removed and not needed in construction shall be spread or disposed of so that it will not interfere with the functioning of the swale.

5. Perimeter swales shall have a minimum grade of one percent and the bottom shall be level.

6. A. Diverted runoff from a protected or stabilized upland area shall outlet directly onto an undisturbed stabilized area, level spreader or into a grade stabilization structure.

   B. Diverted runoff from a disturbed or exposed upland area shall be conveyed to a sediment trapping device such as a sediment trap or a sediment basin or within an area protected by any of these practices.

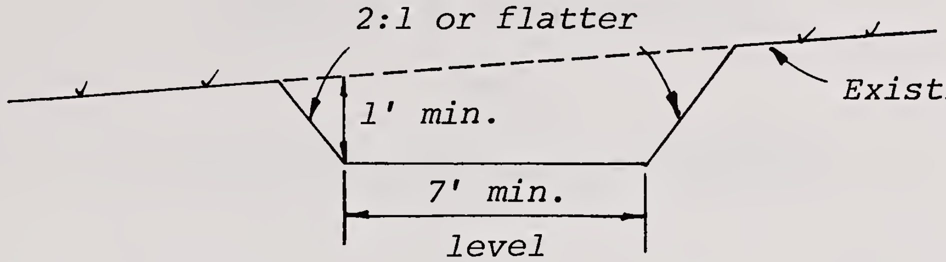
7. Stabilization shall be: (1) in accordance with the Standard & Specifications for Grassed Waterway; or (2) by lining the flow area with stone that meets MSHA size No. 2 or AASHTO M43 size No. 2 or 24 in a layer at least 3 inches in thickness and pressed into the soil. The lining shall extend across the bottom and up both sides of the channel a height of at least 8 inches vertically above the bottom.

8. Periodic inspection and required maintenance shall be provided.

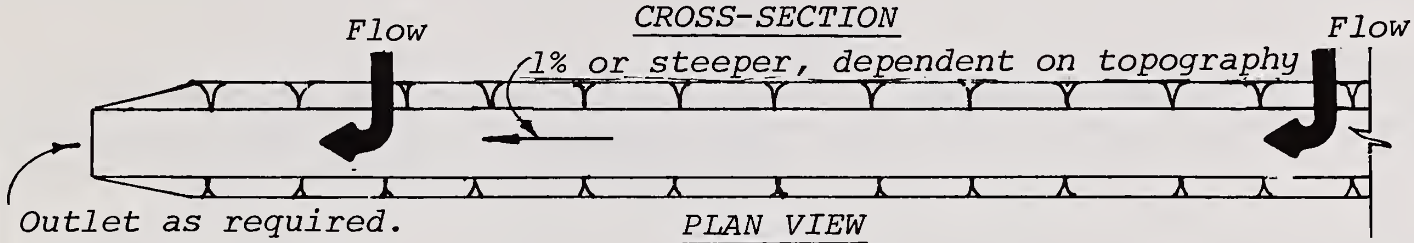
See the following page for Standard Drawing PS-1.

PERIMETER SWALE*

(not to scale)



CROSS-SECTION



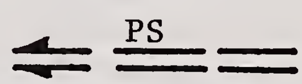
PLAN VIEW

Construction Specifications

1. All trees, brush, stumps, obstructions, and other objectionable material shall be removed and disposed of so as not to interfere with the proper functioning of the swale.
2. The swale shall be excavated or shaped to line, grade, and cross section as required to meet the criteria specified herein and be free of bank projections or other irregularities which will impede normal flow.
3. Fills shall be compacted as needed to prevent unequal settlement that would cause damage in the completed swale.
4. All earth removed and not needed in construction shall be spread or disposed of so that it will not interfere with the functioning of the swale.
5. Perimeter swales shall have a minimum grade of one percent and the bottom shall be level.
6. A. Diverted runoff from a protected or stabilized upland area shall outlet directly onto an undisturbed stabilized area, level spreader or into a grade stabilization structure.
   B. Diverted runoff from a disturbed or exposed upland area shall be conveyed to a sediment trapping device such as a sediment trap or a sediment basin or within an area protected by any of these practices.
7. Stabilization shall be: (1) in accordance with the Standard and Specifications for Grassed Waterway; or (2) by lining the flow area with stone that meets MSHA size No. 2 or AASHTO M43 size No. 2 or 24 in a layer at least 3 inches in thickness and pressed into the soil. The lining shall extend across the bottom and up both sides of the channel a height of at least 8 inches vertically above the bottom.
8. Periodic inspection and required maintenance shall be provided.

* Drainage area less than 5 acres

Standard Symbol



U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE College Park, Md.	PERIMETER SWALE	Standard Drawing PS-1

STANDARD AND SPECIFICATIONS

FOR

STABILIZED CONSTRUCTION ENTRANCE

Definition

A stabilized pad of crushed stone located at any point where traffic will be entering or leaving a construction site to or from a public right-of-way, street, alley, sidewalk or parking area.

Purpose

The purpose of a stabilized construction entrance is to reduce or eliminate the tracking or flowing of sediment onto public rights-of-way.

Conditions Where Practice Applies

A Stabilized Construction Entrance applies to all points of construction ingress and egress.

Design Criteria

Stone Size - Use MSHA size No. 2 (2-1/2" to 1") or AASHTO designation M43, size No. 2 (2-1/2" to 1-1/2"). (8,9)

Thickness - not less than eight (8) inches.

Width - not less than full width of all points of ingress or egress.

Length - as required, but not less than 50 feet.

Maintenance

The entrance shall be maintained in a condition which will prevent tracking or flowing of sediment onto public rights-of-way. This may require periodic top dressing with additional stone as conditions demand and repair and/or cleanout of any measures used to trap sediment. All sediment spilled, dropped, washed or tracked onto public rights-of-way must be removed immediately.

When necessary, wheels must be cleaned to remove sediment prior to entrance onto public right-of-way. When washing is required, it shall be done on an area stabilized with crushed stone which drains into an approved sediment trap or sediment basin. All sediment shall be prevented from entering any storm drain, ditch, or watercourse through use of sand bags, gravel, boards or other approved methods.

See Standard Drawing SCE-1.

Construction Specifications

1. Stone size - Use MSHA size No. 2 (2-1/2" to 1") or AASHTO designation M43, size No. 2 (2-1/2" to 1-1/2"). Use crushed stone.

2. Length - As effective, but not less than 50 feet.

3. Thickness - Not less than eight (8) inches.

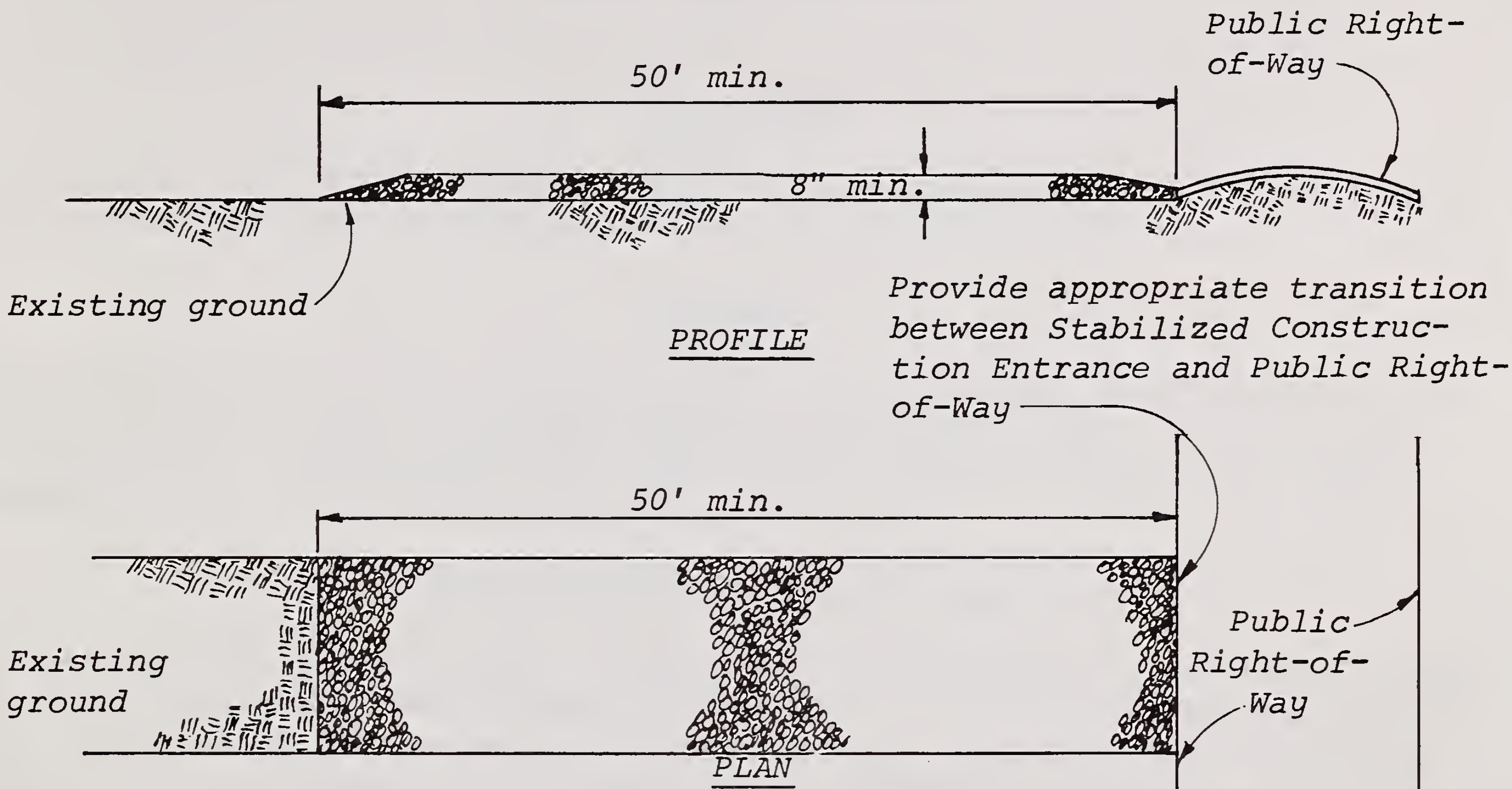
4. Width - Not less than full width of all points of ingress or egress.

5. Washing - When necessary, wheels shall be cleaned to remove sediment prior to entrance onto public right-of-way. When washing is required, it shall be done on an area stabilized with crushed stone which drains into an approved sediment trap or sediment basin. All sediment shall be prevented from entering any storm drain, ditch, or watercourse through use of sand bags, gravel, boards or other approved methods.

6. Maintenance - The entrance shall be maintained in a condition which will prevent tracking or flowing of sediment onto public rights-of-way. This may require periodic top dressing with additional stone as conditions demand and repair and/or cleanout of any measures used to trap sediment. All sediment spilled, dropped, washed or tracked onto public rights-of-way must be removed immediately.

STABILIZED CONSTRUCTION ENTRANCE

(not to scale)



Construction Specifications

1. Stone size - Use MSHA size No. 2 (2-1/2" to 1") or AASHTO designation M43, size No. 2 (2-1/2" to 1-1/2"). Use crushed stone.
2. Length - As effective, but not less than 50 feet.
3. Thickness - Not less than eight (8) inches.
4. Width - Not less than full width of all points of ingress or egress.
5. Washing - When necessary, wheels shall be cleaned to remove sediment prior to entrance onto public right-of-way. When washing is required, it shall be done on an area stabilized with crushed stone which drains into an approved sediment trap or sediment basin. All sediment shall be prevented from entering any storm drain, ditch, or watercourse through use of sand bags, gravel, boards or other approved methods.
6. Maintenance - The entrance shall be maintained in a condition which will prevent tracking or flowing of sediment onto public rights-of-way. This may require periodic top dressing with additional stone as conditions demand and repair and/or cleanout of any measures used to trap sediment. All sediment spilled, dropped, washed or tracked onto public rights-of-way must be removed immediately.

Standard Symbol 

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE College Park, Md.	STABILIZED CONSTRUCTION ENTRANCE	Standard Drawing SCE-1

STANDARD AND SPECIFICATIONS

FOR

STONE OUTLET STRUCTURE

Definition

A temporary crushed stone dike installed in conjunction with and as a part of a diversion dike, interceptor dike, or perimeter dike.

Purpose

The purpose of the stone outlet structure is to provide a protected outlet for a diversion dike, interceptor dike, or perimeter dike, to provide for diffusion of concentrated flow, and to allow the area behind the dike to dewater.

Conditions Where Practice Applies

Stone outlet structures apply to any point of discharge where there is need to dispose of runoff at a protected outlet or to diffuse concentrated flow for the duration of the period of construction. When the entire drainage area to the structure is not stabilized, a sediment trap must be provided in conjunction with the stone outlet structure (See Standard and Specifications for Sediment Trap).

Design Criteria

A stone outlet structure shall be used only where the contributing watershed is less than five acres. The minimum length, in feet, of the crest of the stone outlet structure shall be equal to six times the number of acres of contributing drainage area. The crest of the stone dike shall be at least six inches lower than the lowest elevation of the top of the earth dike and shall be level. The stone shall be crushed stone. Gravel may be used only if crushed stone is not available. The stone shall meet MSHA size No. 2 or AASHTO designation M43, size No. 2 or 24. See Standard Drawing SOS-1 for details.(8,9)

Outlet

The stone outlet structure shall be located so as to discharge onto an already stabilized area or into a stable watercourse. Stabilization shall consist of complete vegetal cover, paving, etc., sufficiently established to be erosion resistant.

Construction Specifications

1. The stone shall be crushed stone. Gravel may be used only if crushed stone is not available. The stone shall meet MSHA Size No. 2 or AASHTO designation M43, Size No. 2 or 24.

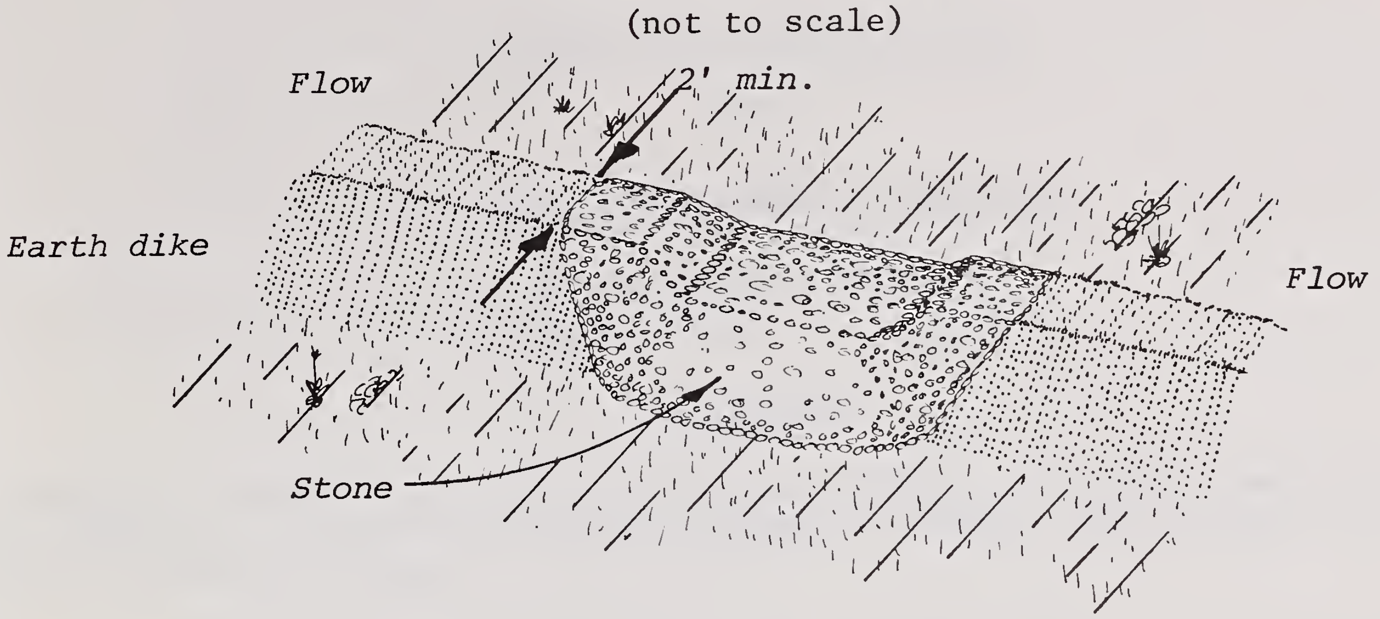
2. The crest of the stone dike shall be at least six inches lower than the lowest elevation of the top of the earth dike and shall be level.

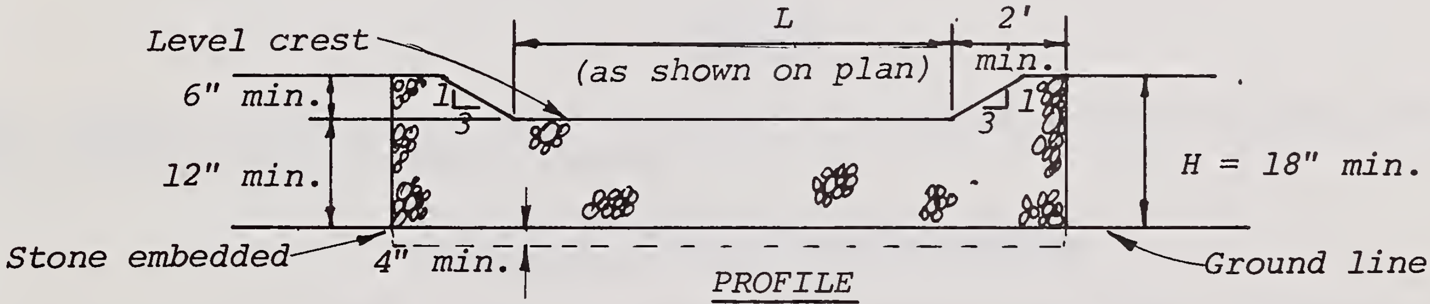
3. Stone of the outlet structure shall be embedded into the soil a minimum of four inches.

4. The minimum length, in feet, of the crest of the stone outlet structure shall be equal to six times the number of acres of contributing drainage area.

5. The stone outlet structure shall be inspected after each rain, and the stone shall be replaced when the structure ceases to function as intended for such reasons as silt accumulation among the stone, washout and construction traffic damage.

STONE OUTLET STRUCTURE*
(not to scale)





PROFILE

Construction Specifications

1. The stone shall be crushed stone. Gravel may be used if crushed stone is not available. The stone shall meet MSHA Size No. 2 or AASHTO designation M43 Size No. 2 or 24.
2. The crest of the stone dike shall be at least six inches lower than the lowest elevation of the top of the earth dike and shall be level.
3. The stone outlet structure shall be embedded into the soil a minimum of four inches.
4. The minimum length, in feet, of the crest of the stone outlet structure shall be equal to six times the number of acres of contributing drainage area.
5. The stone outlet structure shall be inspected after each rain, and the stone shall be replaced when the structure ceases to function as intended due to silt accumulation among the stone, washout, construction traffic damage, etc.

SOS
Standard Symbol
L =

* Drainage area less than 5 acres

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE College Park, Md.	STONE OUTLET STRUCTURE	Standard Drawing SOS-1

STANDARD AND SPECIFICATIONS

FOR

GRADE STABILIZATION STRUCTURE

(PAVED CHUTE OR FLUME)

Definition

A temporary channel lined with bituminous concrete, portland cement concrete, or comparable non-erodible material placed to extend from the top of a slope to the bottom of a slope.

Purpose

The purpose of the paved chute or flume is to convey surface runoff safely down slopes without causing erosion.

Conditions Where Practice Applies

A paved chute or flume is to be used where concentrated flow of surface runoff must be conveyed down a slope in order to prevent erosion. The maximum allowable drainage area shall be 36 acres.

Design Criteria

Size Group A

1. The height (H) of the dike at the entrance is at least 1.5 feet.
2. The depth (d) of the chute down the slope is at least 8 inches.
3. The length (L) of the inlet and outlet sections is 5 feet.

Size Group B

1. The height (H) of the dike at the entrance is at least 2 feet.
2. The depth (d) of the chute down the slope is at least 10 inches.
3. The length (L) of the inlet and outlet sections is 6 feet.

Each size group has various bottom widths and allowable drainage areas as shown below:

Size 1/	Bottom Width, b, ft.	Maximum Drainage Area acres	Size 1/	Bottom Width, b, ft.	Maximum Drainage Area acres
A-2	2	5	B-4	4	14
A-4	4	8	B-6	6	20
A-6	6	11	B-8	8	25
A-8	8	14	B-10	10	31
A-10	10	18	B-12	12	36

1/ The size is designated with a letter and a number, such as A-6 which means a chute or flume in Size Group A with a 6 foot bottom width. The selected size shall be shown on the plans.

If a minimum of 75% of the drainage area will have a good grass or woodland cover throughout the life of the structure, the drainage areas listed above may be increased by 50%. If a minimum of 75% of the drainage area will have a good mulch cover throughout the life of the structure, the drainage areas listed above may be increased by 25%.

For dimensions, grades, and construction details, see Standard Drawing GSS-1.

Outlet

When a paved chute or flume of size group B is used the velocity at its outfall shall be checked for erosion potential downstream.

CONSTRUCTION SPECIFICATIONS

1. The structure shall be placed on undisturbed soil or on well compacted fill.

2. The cut or fill slope shall not be steeper than 1.5 horizontal to 1 vertical (1.5:1) and shall not be flatter than 20:1.

3. The top of the earth dike at the entrance and those dikes carrying water to it shall not be lower at any point than the top of the lining at the entrance of the structure.

4. The lining at the entrance to the structure shall extend the distance H above the lining crest as shown in the Standard Drawing GSS-1.

5. The lining shall be placed beginning at the lower end and proceeding up the slope to the upper end. The lining shall be well compacted and free of voids. The lining surface shall be reasonably smooth.

6. The entrance floor at the upper end of the structure shall have a slope toward the outlet of 1/4 to 1/2 inch per foot.

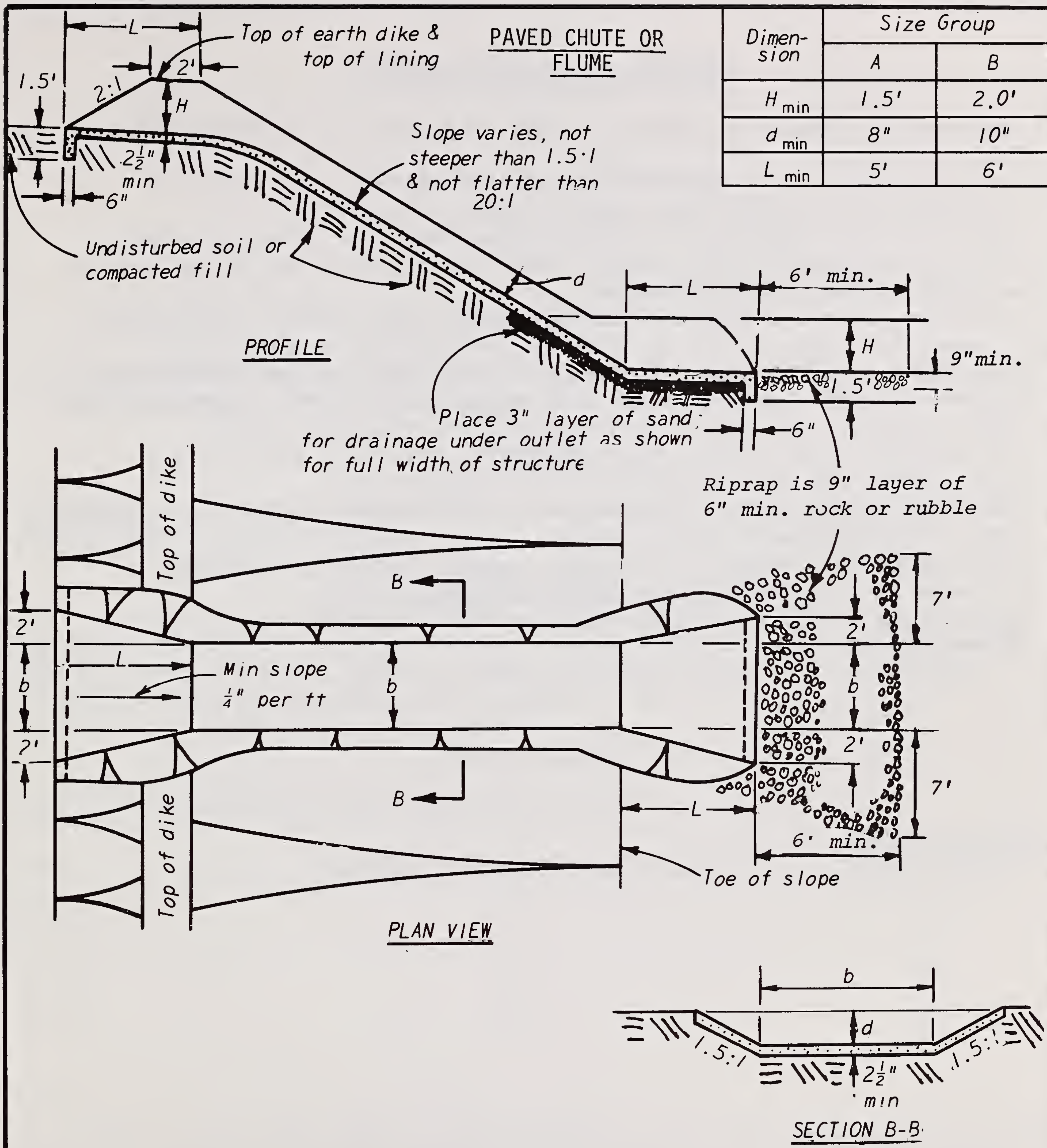
7. The cutoff walls at the entrance and at the end of the discharge aprons shall be continous with the lining.

8. The lining shall consist of portland cement concrete, bituminous concrete or comparable non-erodible material.

9. An energy dissipator of adequate design shall be used to prevent erosion at the outlet.

See the following page for
Standard Drawing GSS-1

Dimen-sion	Size Group	
	A	B
H_{min}	1.5'	2.0'
d_{min}	8"	10"
L_{min}	5'	6'



Standard Symbol $\boxed{\text{GSS-1}}$
(Size group-bottom width)

The size is designated with a letter and a number, such as A-6, which means Size Group A with a 6 ft. bottom width (b). For structure dimensions, see table in upper right hand corner.

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE College Park, Md.	**GRADE STABILIZATION STRUCTURE**	MD-SCS DESIGN STANDARD GSS-1

Construction Specifications

1. The structure shall be placed on undisturbed soil or on well-compacted fill.
2. The cut or fill slope shall not be steeper than 1.5 horizontal to 1 vertical (1.5:1) and shall not be flatter than 20:1.
3. The top of the earth dike at the entrance and those dikes carrying water to it shall not be lower at any point than the top of the lining at the entrance of the structure.
4. The lining at the entrance to the structure shall extend the distance, H, above the lining crest as shown on the Standard Drawing GSS-1.
5. The lining shall be placed beginning at the lower end and proceeding up the slope to the upper end. The lining shall be well compacted and free of voids. The lining surface shall be reasonably smooth.
6. The entrance floor at the upper end of the structure shall have a slope toward the outlet of 1/4 to 1/2 inch per foot.
7. The cutoff walls at the entrance and at the end of the discharge aprons shall be continuous with the lining.
8. The lining shall consist of portland cement concrete, bituminous concrete or comparable non-erodible material.
9. An adequate energy dissipator shall be used to prevent erosion at the outlet.

STANDARD AND SPECIFICATIONS

FOR

GRADE STABILIZATION STRUCTURE

(PIPE SLOPE DRAIN)

Definition

A flexible tubing and/or rigid pipe with prefabricated entrance section temporarily placed to extend from the top of a slope to the bottom of a slope.

Purpose

The purpose of the pipe slope drain is to convey surface runoff safely down slopes without causing erosion.

Conditions Where Practice Applies

Pipe slope drains are to be used where concentrated flow of surface runoff must be conveyed down a slope in order to prevent erosion. The maximum allowable drainage area shall be 5 acres.

Design Criteria

Pipe slope drains are to be sized as follows:

Size	Pipe/tubing Diameter, D, (in.)	Maximum Drainage Area (acres)
PSD-12	12	.5
PSD-18	18	1.5
PSD-21	21	2.5
PSD-24	24	3.5
PSD-30	30	5.0

Inlet

The height of the earth dike at the entrance to the pipe slope drain shall be equal to or greater than the diameter of the pipe, D, + 12". See Standard Drawings, GSS-2 and GSS-3 for details.

Outlet

The pipe slope drain shall outlet onto a riprap apron and then into a stabilized area or stable watercourse. A sediment trapping device shall be used to trap sediment from any sediment laden water conveyed by the pipe slope drain.

Construction Specifications

1. The entrance section and the pipe inlet shall have a slope of 3% or steeper.

2. The top of the earth dike over the inlet pipe and those dikes carrying water to the pipe shall be at least 1 foot higher at all points than the top of the inlet pipe.

3. The inlet pipes shall be corrugated metal pipe with watertight connecting bands.

4. The flexible tubing shall be the same diameter as the inlet pipe and shall be constructed of a durable material with hold-down grommets spaced 10' on centers.

5. The flexible tubing shall be securely fastened to the corrugated metal pipe with metal strapping or watertight connecting collars.

6. The flexible tubing shall be securely anchored to the slope by staking at the grommets provided.

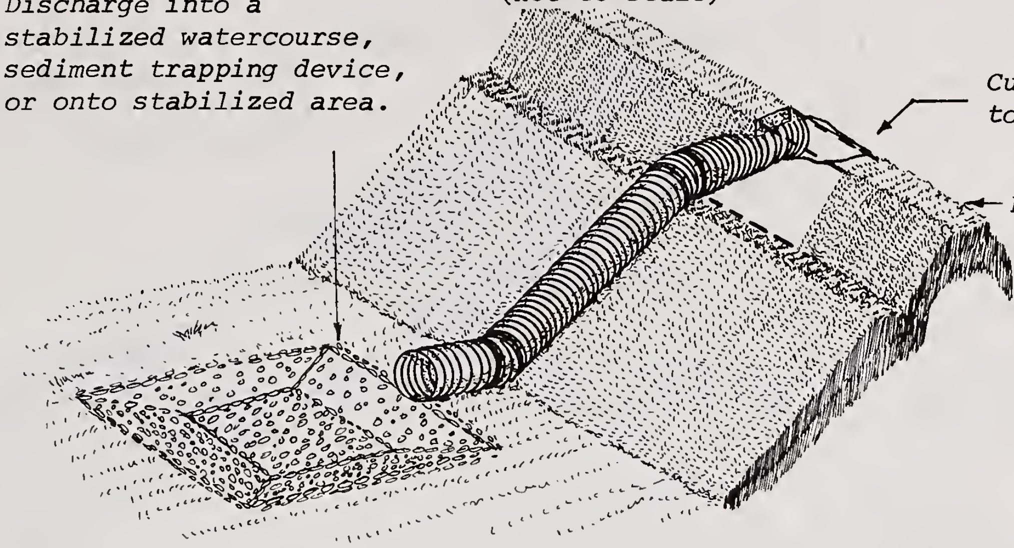
7. A riprap apron shall be provided at the outlet. This shall consist of 6" diameter stone placed as shown on Standard Drawings GSS-2 and GSS-3.

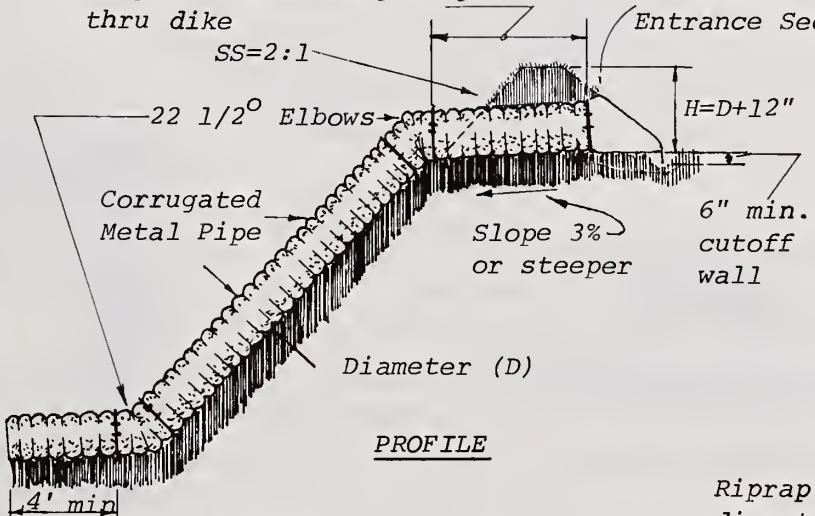
8. The soil around and under the inlet pipe and entrance section shall be hand tamped in 4" lifts to the top of the earth dike.

9. Follow-up inspection and any needed maintenance shall be performed after each storm.

PIPE SLOPE DRAIN (RIGID)*

(not to scale)





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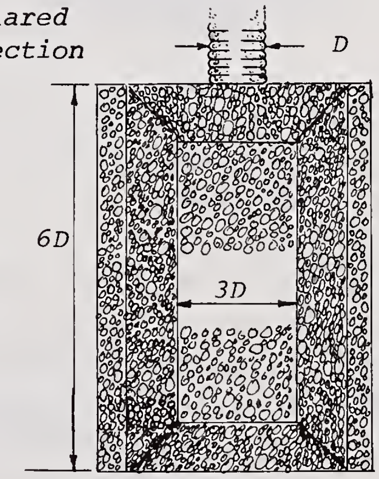


Riprap shall consist of 6" diameter stone placed as shown. Depth of apron shall equal the pipe diameter and riprap shall be a minimum of 12" in thickness.

RIPRAP APRON PLAN

NOTE: Size designation is: PSD-Pipe Diam. (ex., PSD-12=Pipe Slope Drain with 12" diameter pipe)

Construction Specifications

1. The inlet pipe shall have a slope of 3% or steeper.
2. The top of the earth dike over the inlet pipe and those dikes carrying water to the pipe shall be at least 1 foot higher at all points than the top of the inlet pipe.
3. The pipe shall be corrugated metal pipe with water tight connecting bands.
4. A riprap apron shall be provided at the outlet. This shall consist of 6" diameter stone placed as shown on Standard Drawing GSS-2.
5. The soil around and under the inlet pipe and entrance section shall be hand tamped in 4" lifts to the top of the earth dike.
6. Follow-up inspection and any needed maintenance shall be performed after each storm.

Standard Symbol GSS-2 PSD-diam.

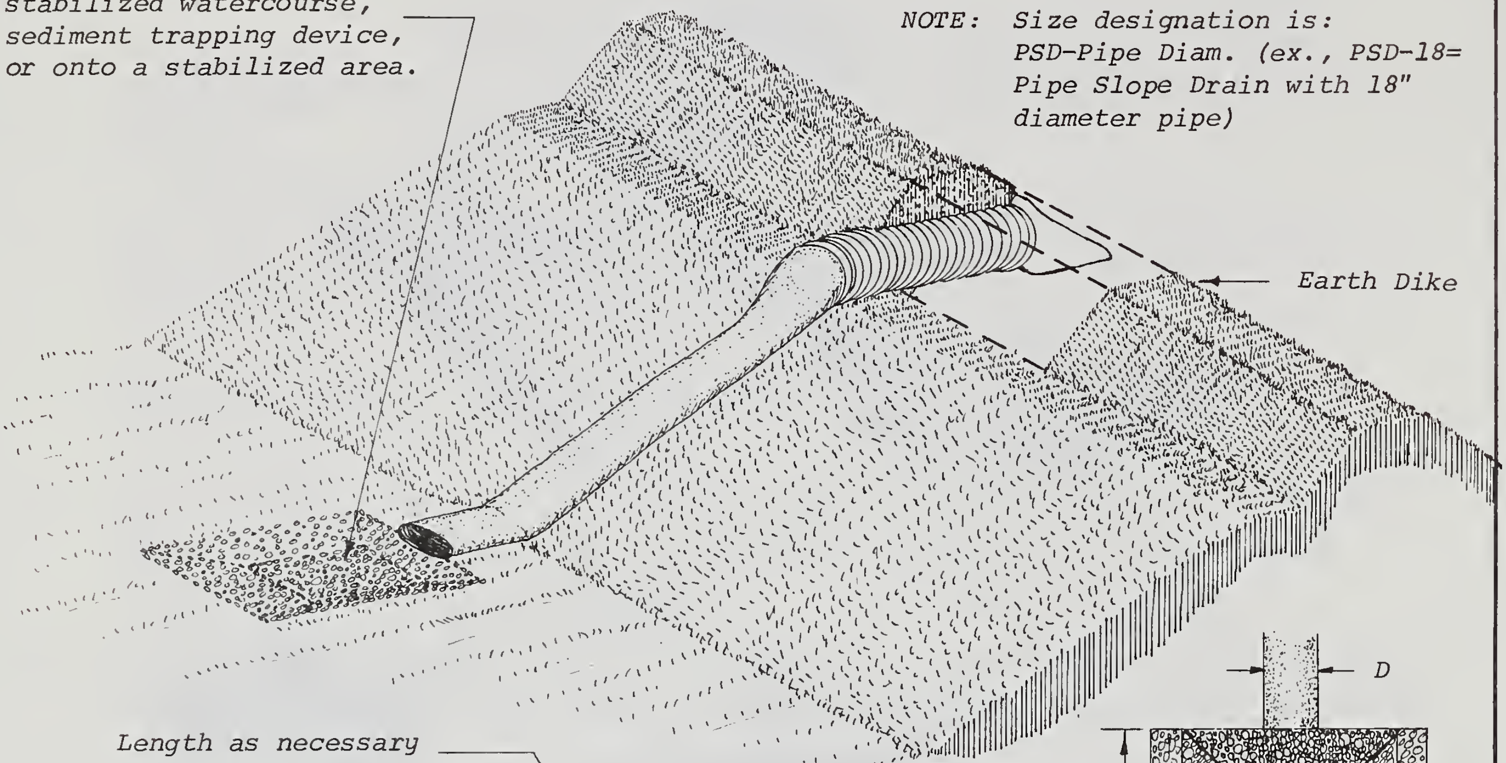
* Drainage area must not exceed 5 acres

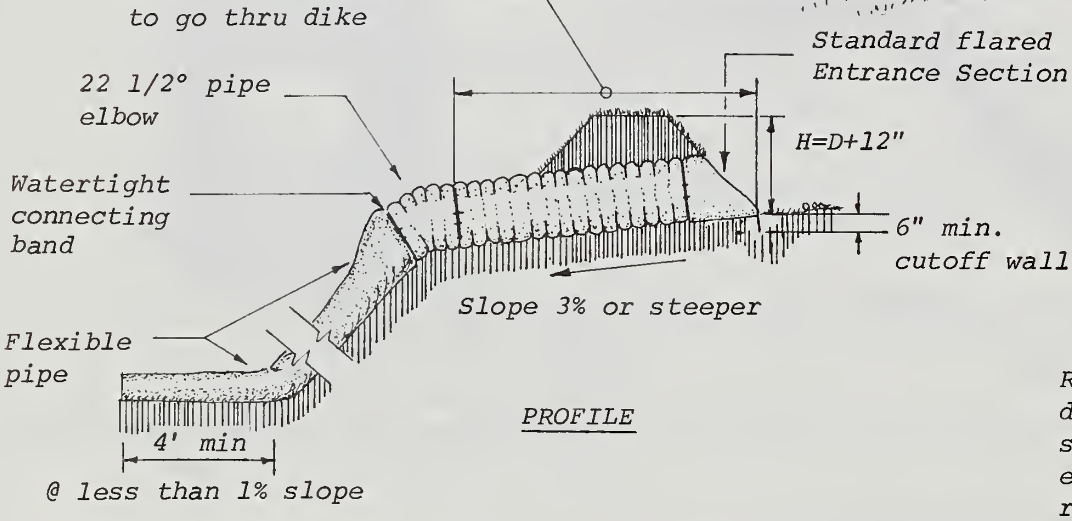
U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE College Park, Md.	GRADE STABILIZATION STRUCTURE	Standard Drawing GSS-2

PIPE SLOPE DRAIN (FLEXIBLE)*

(not to scale)

NOTE: Size designation is: PSD-Pipe Diam. (ex., PSD-18= Pipe Slope Drain with 18" diameter pipe)





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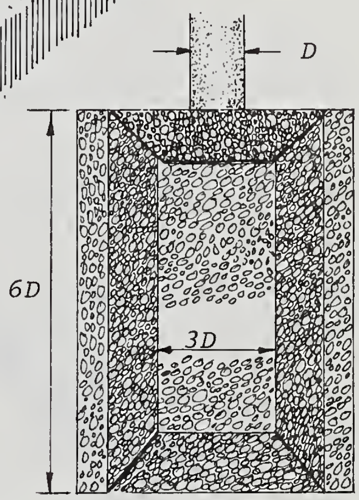


Riprap shall consist of 6" diameter stone placed as shown. Depth of apron shall equal the pipe diameter and riprap shall be a minimum of 12" in thickness.

RIPRAP APRON PLAN

Construction Specifications

1. The inlet pipe shall have a slope of 3% or steeper.
2. The top of the earth dike over the inlet pipe and those dikes carrying water to the pipe shall be at least 1' higher at all points than the top of the inlet pipe.
3. The inlet pipe shall be corrugated metal pipe with watertight connecting bands.
4. The flexible tubing shall be the same diameter as the inlet pipe and shall be constructed of a durable material with hold-down grommets spaced 10' on centers.
5. The flexible tubing shall be securely fastened to the corrugated metal pipe with metal strapping or watertight connecting collars.
6. The flexible tubing shall be securely anchored to the slope by staking at the grommets provided.
7. A riprap apron shall be provided at the outlet. This shall consist of 6" diameter stone placed as shown on Standard Drawing GSS-3.
8. The soil around and under the inlet pipe and entrance section shall be hand tamped in 4" lifts to the top of the earth dike.
9. Follow-up inspection and any needed maintenance shall be performed after each storm.

* Drainage area must not exceed 5 acres.

Standard Symbol [GSS-3] PSD-diam.

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE College Park, Md.	GRADE STABILIZATION STRUCTURE	Standard Drawing GSS-3

STANDARD AND SPECIFICATIONS

FOR

SEDIMENT BASIN

Definition

A temporary barrier or dam constructed across a waterway or at other suitable locations to intercept sediment-laden runoff and to trap and retain the sediment.

Scope

This standard applies to the installation of temporary sediment basins on sites where: (1) failure of the structure would not result in loss of life, damage to homes or buildings, or interruption of use or service of public roads or utilities; (2) the drainage area does not exceed 100 acres, and (3) the basin is to be removed within 36 months after the beginning of construction of the basin.

Permanent (to function more than 36 months) sediment basins, or temporary basins exceeding the classification requirements for Size 1 & 2, or structures that function as a sediment basin and later revert to a permanent pond shall be classified as permanent structures and shall conform to criteria appropriate for permanent structures. These structures shall be designed and constructed to conform to the Water Resources Law of Maryland, Title 8, Subtitle 8, (formerly Article 96A, Section 12), or SCS Engineering Memorandum MD-2 and MD SCS Standard and Specification No. 378. The total volume of permanent sediment basins shall equal or exceed the capacity requirements for temporary basins contained herein. (10,11)

For the purpose of this standard, sediment basins are classified as follows:

Classification of Temporary Sediment Basins

Size	Max. Drainage Area, acres	Max. Height 1/ of Dam, ft.	Min. Embankment Top Width, ft.	Embankment Side Slopes	Anti-Seep Collar Req'd
1	100	10	8	2:1 or flatter	See p. 19.04
2	100	15	10	2-1/2:1 or flatter	Yes

1/ Height is measured from the low point of original ground along the centerline of dam to the top of the dam.

Purpose

The purpose of a Sediment Basin is to intercept sediment-laden runoff and reduce the amount of sediment leaving the disturbed area in order to protect drainage ways, properties, and rights-of-way below the sediment basin from sedimentation.

Conditions Where Practice Applies

A sediment basin applies where physical site conditions or land ownership restrictions preclude the installation of erosion control measures to adequately control runoff, erosion, and sedimentation. It may be used below construction operations which expose critical areas to soil erosion. It remains in effect until the disturbed area is protected against erosion by permanent stabilization.

Design Criteria For Temporary Sediment Basins

Compliance with Laws and Regulations

Design and construction shall comply with state and local laws, ordinances, rules and regulations.

Location

The sediment basin should be located to obtain the maximum storage benefit from the terrain and for ease of cleanout of the trapped sediment. It should be located to minimize interference with construction activities and construction of utilities.

Size of the Basin

The volume of the sediment basin, as measured from the bottom of the basin to the elevation of the crest of the principal spillway shall be at least 67 cubic yards per acre of total drainage area (0.5 watershed inches).(12,13)

Sediment basins shall be cleaned out when the volume as described above is reduced by sedimentation to 27 cubic yards per acre of drainage area (0.2 watershed inches), except in no case shall the sediment level be permitted to build up higher than one foot below the principal spillway crest. This cleanout shall restore the original design volume to the sediment basin. The elevation corresponding to the maximum allowable sediment level shall be determined and shall be stated in the design data as a distance below the top of riser and shall be clearly marked on the riser.

The basin dimensions necessary to obtain the required basin volume as stated above shall be clearly shown on the plans to facilitate plan review, construction and inspection.

Shape of the Basin

The basin configuration shall be such that the effective flow length is equal to at least two times the effective flow width. (i.e., The length to width ratio shall equal 2.0 or greater.) This basin shape may be attained by selecting the basin site, by excavating the basin to the required shape or by the installation of one or more baffles. See the Appendix for the detailed procedures.

Spillway Design

Runoff shall be computed by the method outlined in Chapter 2, Estimating Runoff, "Engineering Field Manual for Conservation Practices" available in the Soil Conservation Service offices, or by other methods acceptable to the local jurisdiction. Runoff computations shall be based upon the soil-cover conditions expected to prevail in the contributing drainage area during the anticipated effective life of the structure. The combined capacities of the principal and emergency spillway shall be sufficient to pass the peak rate of runoff from a ten year frequency storm. (14)

1. Principal spillway - A spillway consisting of a vertical pipe or box type riser joined (watertight connection) to a pipe (barrel) which shall extend through the embankment and outlet beyond the downstream toe of the fill. The minimum capacity of the principal spillway shall be 0.2 cfs per acre of drainage area when the water surface is at the emergency spillway crest elevation. For those basins with no emergency spillway, the principal spillway shall have the capacity to handle the peak flow from a ten year frequency rainfall event. The minimum size of the barrel shall be 8 inches in diameter. See the Appendix for principal spillway sizes and capacities.

    a. Crest elevation - When used in combination with emergency spillways, the crest elevation of the riser shall be one foot below the elevation of the control section of the emergency spillway.

    b. Watertight riser - The riser shall be completely watertight except for the inlet opening at the top or a dewatering opening and shall not have any other holes, leaks, rips or perforations in it.

    c. Dewatering the basin - There are two stages of dewatering the basin: (1) the detention pool which is below the crest of the riser and above the surface of the trapped sediment, and (2) the sediment itself which will have a high water content to the point of being "soupy".

    (1) Means for dewatering the detention pool shall be provided in all basins except those basins used with surface mining, flyash or other special operations. Means for dewatering the pool shall be included in the sediment basin plans submitted for approval and shall be installed during construction of the basin.

Dewatering shall be done in such a manner as to remove the relatively clean water without removing any of the sediment that has settled out and without removing any appreciable quantities of floating debris. Usually the detention pool may be dewatered by making a hole in the riser unless otherwise required by the approving agency. This hole shall not be larger than four inches in diameter and the lower edge of the hole shall not be lower than the required sediment cleanout elevation. For other methods of automatically dewatering the detention pool, see the Appendix.

(2) Dewatering the sediment is not required but does facilitate cleanout of the basin. The only practical means of doing this is by the use of an underdrain. Details of an acceptable underdrain system is given in the Appendix.

d. Anti-vortex device and trash rack - An anti-vortex device and trash rack shall be securely installed on top of the riser and shall be the concentric type as shown in the Appendix.

e. Base - The riser shall have a base attached with a watertight connection and shall have sufficient weight to prevent flotation of the riser. Two approved bases for risers ten feet or less in height are: (1) A concrete base 18" thick with the riser imbedded 6" in the base. (2) A 1/4" minimum thickness steel plate attached to the riser by a continuous weld around the circumference of the riser to form a watertight connection. The plate shall have 2.5 feet of stone, gravel, or tamped earth placed on it to prevent flotation. In either case, each side of the square base shall be twice the riser diameter. For risers greater than ten feet high computations shall be made to check flotation. The minimum factor of safety shall be 1.25 (Downward forces = 1.25 x upward forces).

f. Anti-seep collars - Anti-seep collars shall be installed around the pipe conduit within the normal saturation zone to increase the seepage length at least 10% when any of the following conditions exist:

(1) The settled height of dam exceeds 10 ft., or

(2) The embankment material has a low silt-clay content (Unified Soil Classes SM or GM) and the pipe diameter is 10 inches or greater.

The phreatic line may be approximated with a line drawn downward on a 4:1 slope from the intersection of the normal pool (corresponding to the top of the riser and the upstream face of the embankment.) The seepage length is the length of the flow path of a particle of water along the conduit from the riser to the point of intersection between the approximate phreatic line and

the invert of the pipe conduit. When anti-seep collars are used, the equation for revised seepage length becomes:

$$L_s + 2nV \geq 1.1\ L_s \qquad \text{or} \qquad n \geq \frac{.05L_s}{V}$$

Where: L_s = Saturated length is length, in feet, of pipe between riser and intersection of phreatic line and pipe invert.

n = number of anti-seep collars.

V = vertical projection of collar from pipe, in feet.

See the Appendix for anti-seep collar design.

The anti-seep collar and its connection to the pipe shall be watertight. The maximum spacing, in feet, between collars shall be 14 times the minimum projection of the collar measured perpendicular to the pipe. The anti-seep collar(s) shall be located below the phreatic line in the embankment and should be equally spaced. They shall not be located closer than two feet to a pipe joint. There shall be sufficient distance between collars to allow space for the hauling and compacting equipment.

g. Outlet - An outlet shall be provided including a means of conveying the discharge in an erosion-free manner to an existing stable stream. Drainage easements shall be obtained if this discharge crosses the property line before reaching the stream. These easements shall be in writing, shall be referenced on the sediment basin plan and shall be submitted for review along with the sediment basin plan. Protection against scour at the discharge end of the pipe spillway shall be provided. Measures may include impact basin, riprap, revetment, excavated plunge pools, or other approved methods. See the Standard and Specifications for Storm Drain Outlet Protection.

2. Emergency spillways - Emergency spillways shall not be constructed on fill. The emergency spillway cross-section shall be trapezoidal with a minimum bottom width of eight feet.

a. Capacity - The minimum capacity of the emergency spillway shall be that required to pass the peak rate of runoff from the 10-year frequency storm, less any reduction due to flow in the pipe spillway. Emergency spillway dimensions may be determined by using the method in the Appendix.

b. Velocities - The velocity of flow in the exit channel shall not exceed 6 ft. per second for vegetated channels. For channels with erosion protection other than vegetation, velocities shall be within the non-erosive range for the type of protection used.

c. Erosion protection - Erosion protection shall be provided for by vegetation as prescribed in this publication or by other suitable means such as riprap, asphalt or concrete.

d. Freeboard - Freeboard is the difference between the design high water elevation in the emergency spillway and the top of the settled embankment. If there is no emergency spillway it is the difference between the water surface elevation required to pass the design flow through the pipe and the top of the settled embankment. The freeboard shall be at least one foot.

Embankment Cross-Section

Size 1 Basins - The minimum top width shall be eight feet. The side slopes shall not be steeper than 2:1.

Size 2 Basins - The minimum top width shall be ten feet. The side slopes shall not be steeper than 2-1/2:1.

Entrance of Runoff Into Basin

Points of entrance of surface runoff into excavated sediment basins shall be protected to prevent erosion. Diversions, grade stabilization structures or other water control devices shall be installed as necessary to insure direction of runoff and protect points of entry into the basin. Points of entry should be located so as to insure maximum travel distance of entering runoff to point of exit (the riser) from the basin.

Disposal

The sediment basin plans shall indicate the method(s) of disposing of the sediment removed from the basin. The sediment shall be placed in such a manner that it will not erode from the site. The sediment shall not be deposited downstream from the basin or in or adjacent to a stream or floodplain.

The sediment basin plans shall also show the method of disposing of the sediment basin after the drainage area is stabilized, and shall include the stabilizing of the sediment basin site. Water lying over the trapped sediment shall be removed from the basin by pumping, cutting the top of the riser or other appropriate method prior to removing or breaching the embankment. Sediment shall not be allowed to flush into the stream or drainageway.

Safety

Sediment basins are attractive to children and can be very dangerous. Therefore, they shall be fenced or otherwise made inaccessible to persons or animals unless this is deemed unnecessary due to the remoteness of the site or other circumstances. In any case, local ordinances and regulations regarding health and safety must be adhered to.

CONSTRUCTION SPECIFICATIONS

Site Preparation

Areas under the embankment and any structural works shall be cleared, grubbed, and stripped of topsoil to remove trees, vegetation, roots or other objectionable material. In order to facilitate clean-out and restoration, the pool area (measured at the top of the pipe spillway) will be cleared of all brush and trees.

Cut-off Trench

A cut-off trench shall be excavated along the centerline of earth fill embankments. The minimum depth shall be two feet. The cut-off trench shall extend up both abutments to the riser crest elevation. The minimum bottom width shall be four feet, but wide enough to permit operation of excavation and compaction equipment. The side slopes shall be no steeper than 1:1. Compaction requirements shall be the same as those for the embankment. The trench shall be dewatered during the backfilling-compacting operations.

Embankment

The fill material shall be taken from approved borrow areas. It shall be clean mineral soil free of roots, woody vegetation, oversized stones, rocks, or other objectionable material. Relatively pervious materials such as sand or gravel (Unified Soil Classes GW, GP, SW & SP) shall not be placed in the embankment. Areas on which fill is to be placed shall be scarified prior to placement of fill. The fill material shall contain sufficient moisture so that it can be formed by hand into a ball without crumbling. If water can be squeezed out of the ball, it is too wet for proper compaction. Fill material shall be placed in six to eight-inch thick continuous layers over the entire length of the fill. Compaction shall be obtained by routing the hauling equipment over the fill so that the entire surface of each layer of the fill is traversed by at least one wheel or tread track of the equipment or by the use of a compactor. The embankment shall be constructed to an elevation 10% higher than the design height to allow for settlement if compaction is obtained with hauling equipment. If compactors are used for compaction, the overbuild may be reduced to not less than 5%.

Pipe Spillways

The riser shall be securely attached to the barrel by welding all around and all connections shall be watertight. The barrel and riser shall be placed on a firm smooth soil foundation. The connection between the riser and the riser base shall be watertight. Pervious materials such as sand, gravel, or crushed stone shall not be used as backfill around the pipe or anti-seep collars. The fill material around the pipe spillway shall be placed in four inch layers and compacted under the shoulders and around the pipe to at least the same density as the adjacent embankment. A minimum of two feet of hand compacted backfill shall be placed over the pipe spillway before crossing it

with construction equipment. Steel base plates shall have at least 2-1/2 feet of compacted earth, stone or gravel placed over it to prevent flotation.

Emergency Spillway

The emergency spillway shall not be installed in fill. Elevations, design width, entrance and exit channel slopes are critical to the successful operation of the emergency spillway.

Vegetative Treatment

Stabilize embankment and emergency spillway in accordance with the appropriate vegetative Standard and Specifications immediately following construction.

Erosion and Pollution Control

Construction operations shall be carried out in such a manner that erosion and water pollution will be minimized. State and local laws concerning pollution abatement shall be complied with.

Safety

State and local requirements shall be met concerning fencing and signs, warning the public of hazards of soft sediment and floodwater.

Maintenance

1. Repair all damages caused by soil erosion or construction equipment at or before end of each working day.

2. Sediment shall be removed from basin when it reaches the specified distance below the top of the riser. This sediment shall be placed in such a manner that it will not erode from the site. The sediment shall not be deposited downstream from the embankment or in or adjacent to a stream or flood plain.

Final Disposal

When temporary structures have served their intended purpose and the contributing drainage area has been properly stabilized, the embankment and resulting sediment deposits are to be leveled or otherwise disposed of in accordance with the approved sediment control plan.

INFORMATION TO BE SUBMITTED FOR APPROVAL

Sediment Basin designs and construction plans submitted for review to the Soil Conservation District, or other agency shall include the following:

A. Specific location of the dam.

B. Plan view of dam, storage basin and emergency spillway.

C. Cross section of dam, principal spillway and emergency spillway; profile of emergency spillway.

D. Details of pipe connections, riser to pipe connection, riser base, anti-seep collars, trash rack and anti-vortex device.

E. Runoff calculations for 10-year frequency storm.

F. Storage Computation

    1. Total required

    2. Total available

    3. Level of sediment at which cleanout shall be required; to be stated as a distance from the riser crest to the sediment surface.

G. Calculations showing design of pipe and emergency spillway.

Note: Items E through G above may be submitted using the design data sheet shown in the Appendix.

See the following page for the Appendix
to the Standard & Specifications for Sediment Basin

APPENDIX A-19 SEDIMENT BASIN DESIGN

TEMPORARY SEDIMENT BASIN DESIGN DATA SHEET

Computed by______________ Date______
Checked by_______________ Date______

Project____
Basin #_________ Location____
Total Area draining to basin,________ Acres.

BASIN VOLUME DESIGN

1. Min. required vol. = 67 cu. yds. x ______ac. drainage = _____cu. yds.
2. Vol. of basin = ____________________________________ = _____cu. yds.
3. Excavate_________cu. yds. to obtain required capacity.
   Min. vol. before cleanout = 27 cu. yds. x _____ac. drainage = ____cu. yds.
   Elevation corresponding to scheduled time to clean out_________________
   Distance below top of riser_______________________

DESIGN OF SPILLWAYS

Runoff

4. Q_p=________________________cfs (EFM, Ch. 2 or other appropriate method, attach runoff computation sheet).

Pipe Spillway (Q_{ps})

5. Min. pipe spillway capacity, Q_{ps} = 0.2 x_____ac. drainage =______cfs.
   Note: If there is no emergency spillway, then req'd. Q_{ps} = Q_p= ____cfs.
6. H = _____ft. Barrel length = ______ft.
7. Barrel: Diam.____inches; Q_{ps} = (Q)______x (cor. fac.)_____=______cfs.
8. Riser: Diam.____inches; Length_____ft.; h = _____ft.
9. Trash Rack: Diam._____inches; H= ______inches.

Emergency Spillway Design

10. Emergency Spillway Flow, $Q_{es} = Q_p - Q_{ps}$ = _____-______=________cfs.
11. Width______ft. H_p_____ft.
    Entrance channel slope________________________%
    Exit channel slope____________________________%

ANTI-SEEP COLLAR DESIGN (If Required)

12. y = _____ft.; z = _____:1; pipe slope = _____%, L_s = _____ft.
    Use _____collars, ______'-_____" square; projection = _____ft.

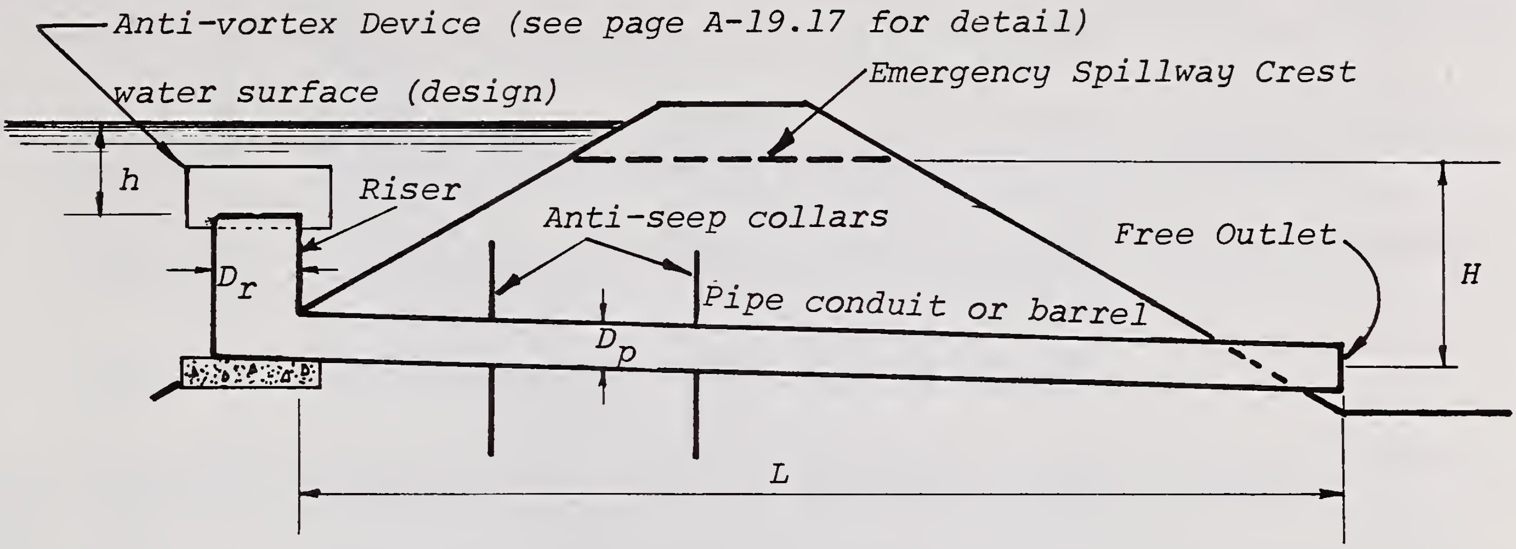
DESIGN ELEVATIONS

13. Riser Crest =____________ Design High Water = __________
    Em. Spwy. Crest =____________ Top of Dam =__________

TEMPORARY SEDIMENT BASIN DESIGN DATA SHEET
INSTRUCTIONS FOR USE OF FORM

1. Minimum required detention volume is 67 cubic yards per acre from each acre of drainage area. Values larger than 67 cubic yards per acre may be used for greater protection. Compute volume using entire drainage area although only part may be disturbed.
2. The volume of a naturally shaped (no excavation in basin) basin may be approximated by the formula $V = 0.4A\ d$, where V is in cubic feet, A is the surface area of the basin, in square feet, and d is the maximum depth of the basin, in feet. Volume may be computed from contour information or other suitable methods.
3. If volume of basin is not adequate for required storage, excavate to obtain the required volume.
4. The method described in the SCS Engineering field Manual, Chapter 2, is the preferred method for runoff computation. If rational method is used to compute runoff, obtain appropriate values for "I" and "C", depending on watershed conditions during development.
5. Required discharge from pipe spillway equals 0.2 cfs/ac. times total drainage area. (This is equivalent to a uniform runoff of 5" per 24 hours). The pipe shall be designed to carry Q_p if site conditions preclude installation of an emergency spillway to protect the structure.
6. Determine value of "H" from field conditions; "H" is interval between the centerline of the outlet pipe and the emergency spillway crest or if there is no emergency spillway, to the design high water.
7. See Pipe Spillway Design Charts, beginning on p. A-19.13.
8. See Riser Inflow Curves.
9. See Trash Rack and Anti-Vortex Device Design, p. A-19.17.
10. Compute Q_{es} by subtracting actual flow carried by the pipe spillway from the total inflow, Q_p.
11. Use appropriate tables to obtain values of H_p, bottom width, and actual Q_{es}. If no emergency spillway is to be used, so state, giving reason(s).
12. See Anti-Seep Collar Design, p. A-19.23, 24.
13. Fill in design elevations. The emergency spillway crest must be set no closer to riser crest than value of h which causes pipe spillway to carry the minimum required Q. Therefore, the elevation difference between spillways shall be equal to the value of h, or one foot, whichever is greater. Design high water is the elevation of the emergency spillway crest plus the value of H_p, or if there is no emergency spillway, it is the elevation of the riser crest plus h required to handle the 10-year storm. Minimum top of dam elevation requires 1.0 ft. of freeboard above design high water.

PIPE SPILLWAY DESIGN



H = Head on pipe spillway (pipe flow), ft. (centerline of outlet to emergency spillway crest or to design high water if no emergency spillway)

h = Head over riser crest, ft.

L = Length of pipe in ft.

D_p = Diameter of pipe conduit (barrel)

D_r = Diameter of riser

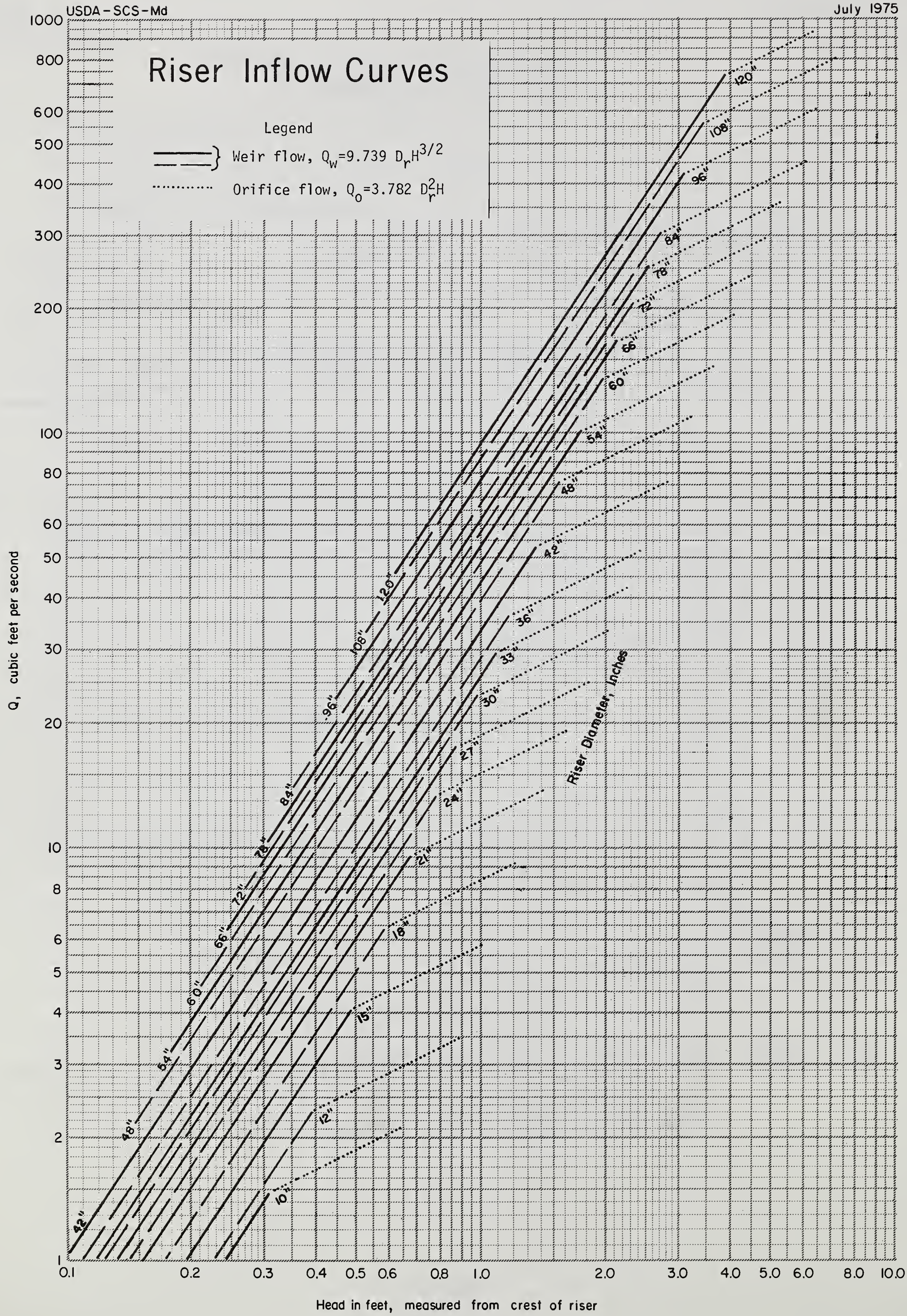
To use charts:

Enter chart, page A-19.15, or A-19.16 with H and required discharge.
Find diameter of pipe conduit that provides equal or greater discharge.
Enter chart, page A-19.14, with actual pipe discharge. Read across to select smallest riser that provides discharge within weir flow portion of rating curve. Read down to find corresponding h required.

Example

Given: Q (required) = 5.8 cfs
L = 60'
H = 9' to centerline of pipe = Free outlet

Find: Pipe size, actual Q and size of riser.
Q of 12" pipe = 6.0 cfs x (correction factor) 1.07 = 6.4 cfs from the Pipe Flow Chart.
From Riser Inflow Curves, smallest riser = 18" (@ h = 0.6)


Riser Inflow Curves
Legend
Weir flow, $Q_w=9.739\ D_r H^{3/2}$
Orifice flow, $Q_o=3.782\ D_r^2 H$
Q, cubic feet per second
Head in feet, measured from crest of riser
Riser Diameter, Inches
1000
800
600
500
400
300
200
100
80
60
50
40
30
20
10
8
6
5
4
3
2
1
0.1
0.2
0.3
0.4
0.5
0.6
0.8
1.0
2.0
3.0
4.0
5.0
6.0
8.0
10.0
10"
12"
15"
18"
21"
24"
27"
30"
33"
36"
42"
48"
54"
60"
66"
72"
78"
84"
96"
108"
120"

PIPE FLOW CHART n = 0.013

FOR REINFORCED CONCRETE PIPE INLET $K_m = K_e + K_b = 0.65$ AND 70 FEET OF REINFORCED CONCRETE PIPE CONDUIT (full flow assumed)

Note correction factors for pipe lengths other than 70 feet

diameter of pipe in inches

H, in feet	12"	15"	18"	21"	24"	30"	36"	42"	48"	54"	60"	66"	72"	78"	84"	90"	96"	102"
1	3.22	5.44	8.29	11.8	15.9	26.0	38.6	53.8	71.4	91.5	114	139	167	197	229	264	302	342
2	4.55	7.69	11.7	16.7	22.5	36.8	54.6	76.0	101	129	161	197	236	278	324	374	427	483
3	5.57	9.42	14.4	20.4	27.5	45.0	66.9	93.1	124	159	198	241	289	341	397	458	523	592
4	6.43	10.9	16.6	23.5	31.8	52.0	77.3	108	143	183	228	278	334	394	459	529	604	683
5	7.19	12.2	18.5	26.3	35.5	58.1	86.4	120	160	205	255	311	373	440	513	591	675	764
6	7.88	13.3	20.3	28.8	38.9	63.7	94.6	132	175	224	280	341	409	482	562	647	739	837
7	8.51	14.4	21.9	31.1	42.0	68.8	102	142	189	242	302	368	441	521	607	699	798	904
8	9.10	15.4	23.5	33.3	44.9	73.5	109	152	202	259	323	394	472	557	685	748	854	966
9	9.65	16.3	24.9	35.3	47.7	78.0	116	161	214	275	342	418	500	590	688	793	905	1025
10	10.2	17.2	26.2	37.2	50.2	82.2	122	170	226	289	361	440	527	622	725	836	954	1080
11	10.7	18.0	27.5	39.0	52.7	86.2	128	178	237	304	379	462	553	653	761	877	1001	1133
12	11.1	18.9	28.7	40.8	55.0	90.1	134	186	247	317	395	482	578	682	794	916	1045	1184
13	11.6	19.6	29.9	42.4	57.3	93.7	139	194	257	330	411	502	601	710	827	953	1088	1232
14	12.0	20.4	31.0	44.1	59.4	97.3	145	201	267	342	427	521	624	736	858	989	1129	1278
15	12.5	21.1	32.1	45.6	61.5	101	150	208	277	354	442	539	646	762	888	1024	1169	1323
16	12.9	21.8	33.2	47.1	63.5	104	155	215	286	366	457	557	667	787	917	1057	1207	1367
17	13.3	22.4	34.2	48.5	65.5	107	159	222	294	377	471	574	688	812	946	1090	1244	1409
18	13.7	23.1	35.2	49.9	67.4	110	164	228	303	388	484	591	708	835	973	1121	1280	1450
19	14.0	23.7	36.1	51.3	69.2	113	168	234	311	399	497	607	727	858	1000	1152	1315	1489
20	14.4	24.3	37.1	52.6	71.0	116	173	240	319	409	510	623	746	880	1026	1182	1350	1528
21	14.7	24.9	38.0	53.9	72.8	119	177	246	327	419	523	638	764	902	1051	1211	1383	1566
22	15.1	25.5	38.9	55.2	74.5	122	181	252	335	429	535	653	782	923	1076	1240	1415	1603
23	15.4	26.1	39.8	56.5	76.2	125	186	258	342	439	547	668	800	944	1100	1268	1447	1639
24	15.8	26.7	40.6	57.7	77.8	127	189	263	350	448	559	682	817	964	1123	1295	1478	1674
25	16.1	27.2	41.5	58.9	79.4	130	193	269	357	458	571	696	834	984	1147	1322	1509	1708
26	16.4	27.7	42.3	60.0	81.0	133	197	274	364	467	582	710	850	1004	1169	1348	1539	1742
27	16.7	28.3	43.1	61.2	82.5	135	201	279	371	476	593	723	867	1023	1192	1373	1568	1775
28	17.0	28.8	43.9	62.3	84.1	138	204	285	378	484	604	737	883	1041	1214	1399	1597	1808
29	17.3	29.3	44.7	63.4	85.5	140	208	290	384	493	615	750	898	1060	1235	1423	1625	1840
30	17.6	29.8	45.4	64.5	87.0	142	212	294	391	501	625	763	913	1078	1256	1448	1653	1871
L, in feet	Correction Factors For Other Pipe Lengths																	
20	1.30	1.24	1.21	1.18	1.15	1.12	1.10	1.08	1.07	1.06	1.05	1.05	1.04	1.04	1.03	1.03	1.03	1.03
30	1.22	1.18	1.15	1.13	1.12	1.09	1.08	1.06	1.05	1.05	1.04	1.04	1.03	1.03	1.03	1.02	1.02	1.02
40	1.15	1.13	1.11	1.10	1.08	1.07	1.05	1.05	1.04	1.03	1.03	1.03	1.02	1.02	1.02	1.02	1.02	1.02
50	1.09	1.08	1.07	1.06	1.05	1.04	1.04	1.03	1.03	1.02	1.02	1.02	1.02	1.01	1.01	1.01	1.01	1.01
60	1.04	1.04	1.03	1.03	1.03	1.02	1.02	1.02	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01
70	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
80	.96	.97	.97	.97	.98	.98	.98	.99	.99	.99	.99	.99	.99	.99	.99	.99	.99	.99
90	.93	.94	.94	.95	.95	.96	.97	.97	.98	.98	.98	.98	.98	.99	.99	.99	.99	.99
100	.90	.91	.92	.93	.93	.95	.95	.96	.97	.97	.97	.98	.98	.98	.98	.98	.98	.99
120	.84	.86	.87	.89	.90	.91	.93	.94	.94	.95	.96	.96	.96	.97	.97	.97	.97	.98
140	.80	.82	.83	.85	.86	.88	.90	.91	.92	.93	.94	.94	.95	.95	.96	.96	.96	.97
160	.76	.78	.80	.82	.83	.86	.88	.89	.90	.91	.92	.93	.94	.94	.95	.95	.95	.96

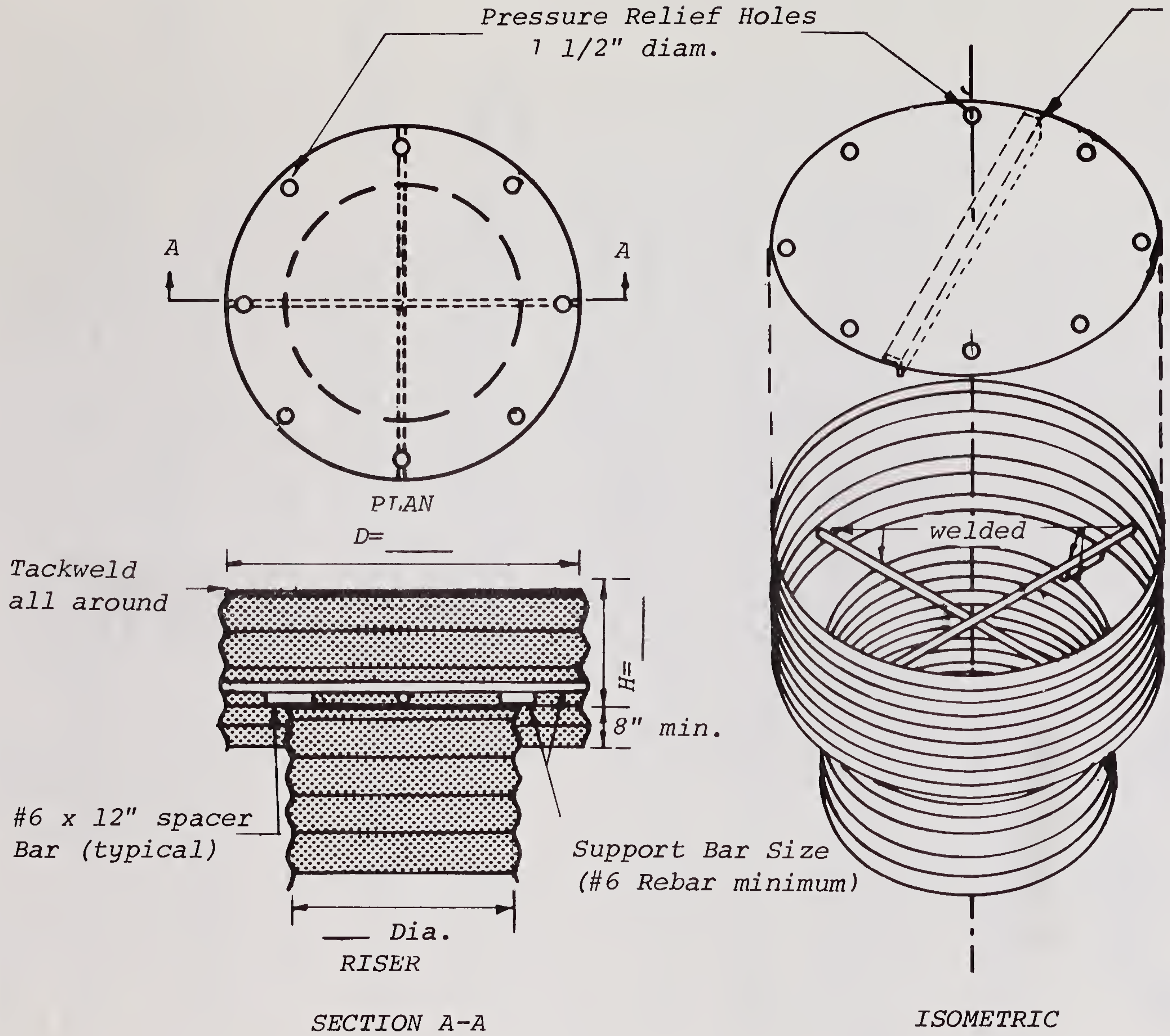
PIPE FLOW CHART n = 0.025

FOR CORRUGATED METAL PIPE INLET $K_m = K_e + K_b$ = 1.0 AND 70 FEET OF CORRUGATED METAL PIPE CONDUIT (full flow assumed)

Note correction factors for pipe lengths other than 70 feet

diameter of pipe in inches

H, in feet	6"	8"	10"	12"	15"	18"	21"	24"	30"	36"	42"	48"	54"	60"	66"	72"	78"	84"	90"	96"	102"
1	0.33	0.70	1.25	1.98	3.48	5.47	7.99	11.0	18.8	28.8	41.1	55.7	72.6	91.8	113	137	163	191	222	255	290
2	0.47	0.99	1.76	2.80	4.92	7.74	11.3	15.6	26.6	40.8	58.2	78.8	103	130	160	194	231	271	314	360	410
3	0.58	1.22	2.16	3.43	6.02	9.48	13.8	19.1	32.6	49.9	71.2	96.5	126	159	196	237	282	331	384	441	502
4	0.67	1.40	2.49	3.97	6.96	10.9	16.0	22.1	37.6	57.7	82.3	111	145	184	226	274	326	383	444	510	580
5	0.74	1.57	2.79	4.43	7.78	12.2	17.9	24.7	42.1	64.5	92.0	125	162	205	253	306	365	428	496	570	648
6	0.82	1.72	3.05	4.86	8.52	13.4	19.6	27.0	46.1	70.6	101	136	178	225	277	336	399	469	544	624	710
7	0.88	1.86	3.30	5.25	9.20	14.5	21.1	29.2	49.8	76.3	109	147	192	243	300	362	431	506	587	674	767
8	0.94	1.99	3.53	5.61	9.84	15.5	22.6	31.2	53.2	81.5	116	158	205	260	320	388	461	541	628	721	820
9	1.00	2.11	3.74	5.95	10.4	16.4	24.0	33.1	56.4	86.5	123	167	218	275	340	411	489	574	666	764	870
10	1.05	2.22	3.94	6.27	11.0	17.3	25.3	34.9	59.5	91.2	130	176	230	290	358	433	516	605	702	806	917
11	1.10	2.33	4.13	6.58	11.5	18.2	26.5	36.6	62.4	95.6	136	185	241	304	376	454	541	635	736	845	962
12	1.15	2.43	4.32	6.87	12.1	19.0	27.7	38.2	65.2	99.9	142	193	252	318	392	475	565	663	769	883	1004
13	1.20	2.53	4.49	7.15	12.6	19.7	28.8	39.8	67.8	104	148	201	262	331	408	494	588	690	800	919	1045
14	1.25	2.63	4.66	7.42	13.0	20.5	29.9	41.3	70.4	108	154	208	272	343	424	513	610	716	830	953	1085
15	1.29	2.72	4.83	7.68	13.5	21.2	30.9	42.8	72.8	112	159	216	281	355	439	531	631	741	860	987	1123
16	1.33	2.81	4.99	7.93	13.9	21.9	32.0	44.2	75.2	115	165	223	290	367	453	548	652	765	888	1019	1160
17	1.37	2.90	5.14	8.18	14.3	22.6	32.9	45.5	77.5	119	170	230	229	378	467	565	672	789	915	1051	1195
18	1.41	2.98	5.29	8.41	14.8	23.2	33.9	46.8	79.8	120	174	236	308	389	480	581	692	812	942	1081	1230
19	1.45	3.06	5.43	8.64	15.2	23.9	34.8	48.1	82.0	126	179	243	316	400	494	597	711	834	967	1111	1264
20	1.49	3.14	5.57	8.87	15.6	24.5	35.7	49.4	84.1	129	184	249	325	410	506	613	729	856	993	1139	1297
21	1.53	3.22	5.71	9.09	15.9	25.1	36.6	50.6	86.2	132	188	255	333	421	519	628	747	877	1017	1168	1329
22	1.56	3.29	5.85	9.30	16.3	25.7	37.5	51.8	88.2	135	193	261	341	430	531	643	765	898	1041	1195	1360
23	1.60	3.37	5.98	9.51	16.7	26.2	38.3	53.0	90.2	138	197	267	348	440	543	657	782	918	1064	1222	1390
24	1.63	3.44	6.11	9.72	17.0	26.8	39.1	54.1	92.1	141	201	273	356	450	555	671	799	937	1087	1248	1420
25	1.66	3.51	6.23	9.92	17.4	27.4	39.9	55.2	94.0	144	206	279	363	459	566	685	815	957	1110	1274	1450
26	1.70	3.58	6.36	10.1	17.7	27.9	40.7	56.3	95.9	147	210	284	370	468	577	699	831	976	1132	1299	1478
27	1.73	3.65	6.48	10.3	18.1	28.4	41.5	57.4	97.7	150	214	290	377	477	588	712	847	994	1153	1324	1507
28	1.76	3.72	6.60	10.5	18.4	29.0	42.3	58.4	99.5	153	218	295	384	486	599	725	863	1013	1174	1348	1534
29	1.79	3.78	6.71	10.7	18.7	29.5	43.0	59.5	101	155	221	300	391	494	610	738	878	1030	1195	1372	1561
30	1.82	3.85	6.83	10.9	19.1	30.0	43.7	60.5	103	158	225	305	398	503	620	750	893	1048	1216	1396	1588
L, in feet	Correction Factors For Other Pipe Lengths																				
20	1.69	1.63	1.58	1.53	1.47	1.42	1.37	1.34	1.28	1.24	1.20	1.18	1.16	1.14	1.13	1.11	1.10	1.10	1.09	1.08	1.08
30	1.44	1.41	1.39	1.36	1.32	1.29	1.27	1.24	1.21	1.18	1.15	1.13	1.12	1.11	1.10	1.09	1.08	1.07	1.07	1.06	1.06
40	1.28	1.27	1.25	1.23	1.21	1.20	1.18	1.17	1.14	1.12	1.11	1.10	1.09	1.08	1.07	1.06	1.06	1.05	1.05	1.05	1.04
50	1.16	1.16	1.15	1.14	1.13	1.12	1.11	1.10	1.09	1.08	1.07	1.06	1.06	1.05	1.05	1.04	1.04	1.04	1.03	1.03	1.03
60	1.07	1.07	1.07	1.06	1.06	1.05	1.05	1.05	1.04	1.04	1.03	1.03	1.03	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.01
70	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
80	.94	.94	.95	.95	.95	.95	.96	.96	.96	.97	.97	.97	.98	.98	.98	.98	.98	.98	.99	.99	.99
90	.89	.89	.90	.90	.91	.91	.92	.92	.93	.94	.94	.95	.95	.96	.96	.96	.97	.97	.97	.97	.94
100	.85	.85	.86	.86	.87	.88	.89	.89	.90	.91	.92	.93	.93	.94	.94	.95	.95	.95	.96	.96	.94
120	.78	.79	.79	.90	.81	.82	.83	.83	.85	.86	.87	.89	.89	.90	.91	.89	.92	.93	.93	.94	.92
140	.72	.73	.74	.75	.76	.77	.78	.79	.81	.82	.84	.85	.86	.87	.88	.86	.89	.90	.91	.91	.90
160	.68	.69	.69	.70	.71	.73	.74	.75	.77	.79	.80	.82	.83	.84	.85	.92	.87	.88	.89	.89	



Top stiffener (if required) is ____x____x____ angle welded to top and oriented perpendicular to corrugations.

Top is ____ gage corrugated metal or 1/8" steel plate. Pressure relief holes may be ommitted, if ends of corrugations are left fully open when corrugated top is welded to cylinder.

Cylinder is ____ gage corrugated metal pipe or fabricated from 1/8" steel plate.

Notes:
1) The cylinder must be firmly fastened to the top of the riser.
2) Support bars are welded to the top of the riser or attached by straps bolted to top of riser.

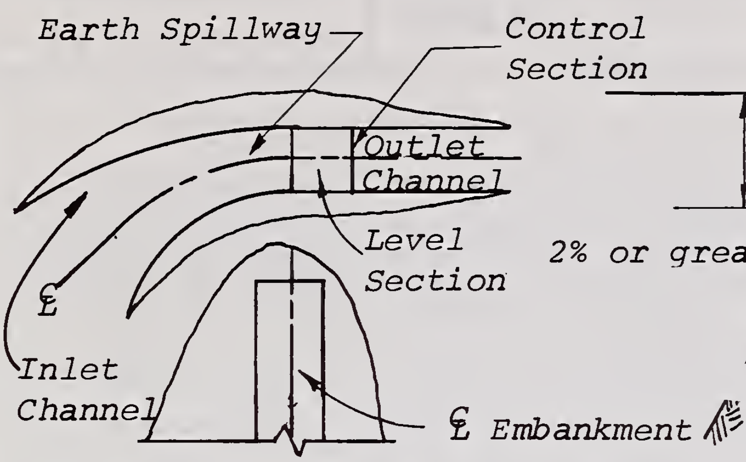
CONCENTRIC TRASH RACK AND ANTI-VORTEX DEVICE
(not to scale)

CONCENTRIC TRASH RACK AND ANTI-VORTEX DEVICE

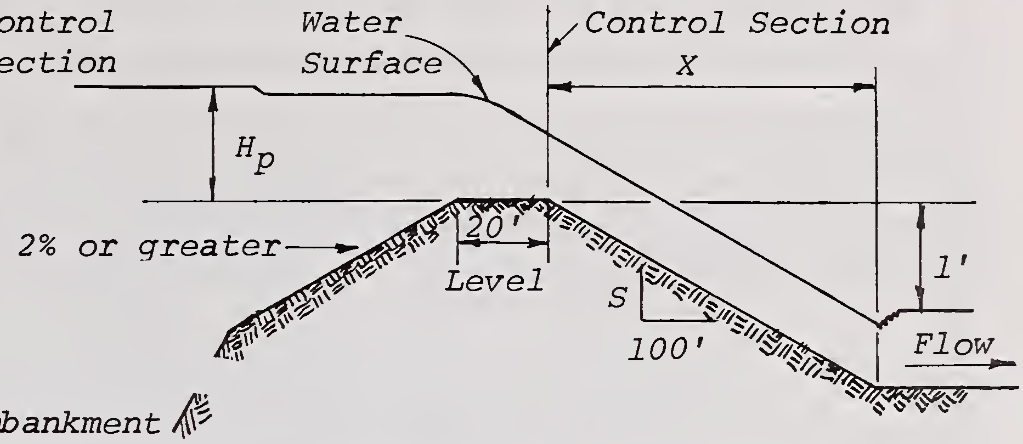
DESIGN TABLE

Riser Diam., in.	Cylinder Diam. in.	Cylinder Thick., gage	H, in.	Minimum Size Support Bar	Minimum Top Thickness	Minimum Top Stiffener
12	18	16	6	#6 Rebar	16 ga.	-
15	21	16	7	"	"	-
18	27	16	8	"	"	-
21	30	16	11	"	"	-
24	36	16	13	"	14 ga.	-
27	42	16	15	"	14 ga.	-
36	54	14	17	#8 Rebar	12 ga.	-
42	60	14	19	"	"	-
48	72	12	21	1-1/4" pipe or 1-1/4x1-1/4x1/4 angle	10 ga.	-
54	78	12	25	"	"	-
60	90	12	29	1-1/2" pipe or 1-1/2x1-1/2x1/4 angle	8 ga.	-
66	96	10	33	2" pipe or 2x2x3/16 angle	8 ga., w/stiffener	2x2x1/4 angle
72	102	10	36	"	"	2-1/2x2-1/2x 1/4 angle
78	114	10	39	2-1/2" pipe or 2x2x1/4 angle	"	"
84	120	10	42	2-1/2" pipe or 2-1/2x2-1/2x1/4 angle	"	2-1/2x2-1/2x 5/16 angle

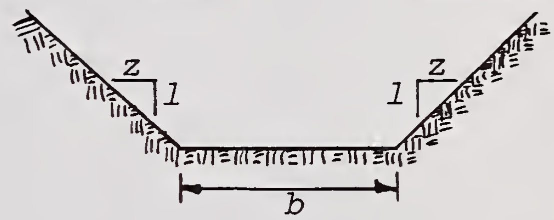
Note: The criteria for sizing the cylinder is that the area between the inside of the cylinder and the outside of the riser is equal to or greater than the area inside the riser. Therefore, the above table is invalid for use with concrete pipe risers.



PLAN OF EARTH SPILLWAY



PROFILE ALONG ℄ OF EARTH SPILLWAY



CROSS SECTION OF EARTH SPILLWAY AT CONTROL SECTION

LEGEND

n = Manning's Coefficient of Roughness.

H_p = Difference in Elevation between Crest of Earth Spillway at the Control Section and Water Surface in Reservoir, in feet.

b = Bottom Width of Earth Spillway at the Control Section, in feet.

Q = Total Discharge, in cfs.

V = Velocity, in feet per second, that will exist in Channel below Control Section, at Design Q, if constructed to slope (S) that is shown.

S = Flattest Slope (S), in %, allowable for Channel below Control Section.

X = Minimum Length of Channel below Control Section, in feet.

z = Side Slope Ratio.

NOTES:

1) For a given H_p a decrease in the exit slope from S as given in the table decreases spillway discharge but increasing the exit slope from S does not increase discharge. If an exit slope (S_e) steeper than S is used, then velocity (V_e) in the exit channel will increase according to the following relationship:

$$V_e = V\left(\frac{S_e}{S}\right)^{0.3}$$

2) Data to right of heavy vertical lines on drawings should be used with caution, as the resulting sections will be either poorly proportioned or have velocities in excess of 6 ft/sec.

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE College Park, Md.	DESIGN DATA FOR EARTH SPILLWAYS	Ref: Engineering Field Manual

DESIGN DATA FOR EARTH SPILLWAYS

SIDE SLOPE 2:1
VEGETATED n=0.040

STAGE (Hp) IN FEET	SPILLWAY VARIABLES	BOTTOM WIDTH (b) IN FEET 8	10	12	14	16	16	20	22	24	26	28	30	32	34	36	38	40
0.5	Q	6	7	8	10	11	13	14	15	17	18	20	21	22	24	25	27	28
	V	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
	S	3.9	3.9	3.9	3.9	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
	X	32	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33
0.6	Q	8	10	12	14	16	18	20	22	24	26	28	36	32	34	35	37	39
	V	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
	S	3.7	3.7	3.7	3.7	3.6	3.7	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
	X	36	36	36	36	36	36	37	37	37	37	37	37	37	37	37	37	37
0.7	Q	11	13	16	18	20	23	25	28	30	33	35	38	41	43	44	46	48
	V	3.2	3.2	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
	S	3.5	3.5	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
	X	39	40	40	40	41	41	41	41	41	41	41	41	41	41	41	41	41
0.8	Q	13	16	19	22	26	29	32	35	38	42	45	46	48	51	54	57	60
	V	3.5	3.5	3.5	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
	S	3.3	3.3	3.3	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
	X	44	44	44	44	45	45	45	45	45	45	45	45	45	45	45	45	45
0.9	Q	17	20	24	28	32	35	39	43	47	51	53	57	60	64	68	71	75
	V	3.7	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
	S	3.2	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
	X	47	47	48	48	48	48	48	48	48	49	49	49	49	49	49	49	49
1.0	Q	20	24	29	33	38	42	47	51	56	61	63	69	72	77	81	86	90
	V	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
	S	3.1	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
	X	51	51	51	51	52	52	52	52	52	52	52	52	52	52	52	52	52
1.1	Q	23	28	34	39	44	49	54	60	65	70	74	79	84	89	95	100	105
	V	4.2	4.2	4.2	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
	S	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
	X	55	55	55	55	55	55	55	56	56	56	56	56	56	56	56	56	56
1.[illegible]	Q	28	33	40	45	51	58	64	69	76	80	86	92	98	104	110	116	122
	V	4.4	44	4.4	4.4	4.4	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
	S	2.8	2.9	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
	X	58	58	59	59	59	59	59	59	60	60	80	60	60	60	60	60	60
1.3	Q	32	38	46	53	59	65	73	80	86	91	99	106	112	119	125	133	140
	V	4.5	4.6	4.6	4.6	4.6	4.6	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7
	S	2.8	2.8	2.8	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
	X	62	62	62	83	63	63	63	63	63	63	63	64	64	64	64	64	64
1.4	Q	37	44	51	59	66	74	82	90	96	103	111	119	127	134	142	150	158
	V	4.7	4.8	4.8	4.9	4.8	4.8	4.8	4.8	4.8	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9
	S	2.8	2.7	2.7	2.7	2.7	2.7	2.7	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
	X	65	66	66	66	66	67	67	67	67	67	67	68	68	68	68	68	69
1.5	Q	41	50	58	66	75	85	92	101	108	116	125	133	142	150	160	169	178
	V	4.8	4.9	4.9	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.1	5.1	5.1
	S	2.7	2.7	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.5	2.5	2.5
	X	69	69	70	70	71	71	71	71	71	71	71	72	72	72	72	72	72
1.6	Q	46	56	65	75	84	94	104	112	122	132	142	149	158	168	178	167	197
	V	5.0	5.1	5.1	5.1	5.1	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2
	S	2.6	2.6	2.6	2.6	2.9	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	X	72	74	74	75	75	76	76	76	76	76	76	76	76	76	76	76	76
1.7	Q	52	62	72	83	94	105	115	126	135	145	156	167	175	187	196	206	217
	V	5.2	5.2	5.2	5.3	5.3	5.3	5.3	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4
	S	2.6	2.6	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.9	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	X	76	78	79	80	80	80	80	80	80	80	80	80	80	80	80	80	80
1.8	Q	58	69	81	93	104	116	127	138	150	160	171	182	194	204	214	226	233
	V	5.3	5.4	5.4	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.6	5.6	5.6	5.6	5.6	5.6
	S	2.5	2.5	2.5	2.5	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
	X	80	82	83	84	84	84	84	84	84	84	84	84	84	84	84	84	84
1.9	Q	64	76	88	102	114	127	140	152	164	175	188	201	213	225	235	248	260
	V	5.5	5.5	5.5	5.6	5.6	5.6	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7
	S	2.5	2.5	2.5	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
	X	84	85	86	87	88	88	88	88	88	68	88	88	86	88	88	88	88
2.0	Q	71	83	97	111	125	138	153	164	178	193	204	218	232	245	256	269	283
	V	5.6	5.7	5.7	5.7	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.9	5.9	5.9	5.9	5.9	5.9
	S	2.5	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.3	2.3	2.3	2.3	2.3	2.5	2.3	2.3	2.3
	X	88	90	91	91	91	91	92	92	92	92	92	92	92	92	92	92	92
1.4	Q	77	91	107	122	135	149	162	177	192	207	220	234	250	267	276	291	305
	V	5.7	5.8	5.9	5.9	5.9	5.9	5.9	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
	S	2.4	2.4	2.4	2.4	2.4	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
	X	92	93	95	95	95	95	95	95	95	96	96	96	96	96	96	96	96
2.2	Q	84	100	116	131	146	163	177	194	210	224	2.38	253	269	288	301	314	330
	V	5.9	5.9	6.0	6.0	6.0	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.2	6.2	6.2	6.2
	S	2.4	2.4	2.4	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.5	2.3	2.3	2.3
	X	96	98	99	99	99	99	99	100	100	100	100	100	100	100	100	100	100
2.3	Q	90	108	124	140	158	175	193	208	226	243	258	275	292	306	323	341	354
	V	6.0	6.1	6.1	6.1	6.2	6.2	6.2	6.2	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3
	S	2.4	2.4	2.3	2.3	2.3	2.3	2.3	2.3	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
	X	100	102	102	103	103	103	104	104	104	105	105	105	105	105	105	105	105
2.4	Q	99	116	136	152	170	189	206	224	241	260	275	294	312	327	346	364	378
	V	6.1	6.2	6.2	6.3	6.3	6.3	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4
	S	2.3	2.3	2.3	2.3	2.3	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
	X	105	105	106	107	107	108	108	108	108	109	109	109	109	109	109	109	109

REFERENCE	U. S. DEPARTMENT OF AGRICULTURE	RTSC-NE-ENG.
Engineering Field Manual	SOIL CONSERVATION SERVICE ENGINEERING & WATERSHED PLANNING UNIT UPPER DARBY, PENNSYLVANIA	1110 SHEET 4 OF 11

ANTI-SEEP COLLAR DESIGN

This procedure provides the anti-seep collar dimensions for only temporary sediment basins to increase the seepage length by 10% for various pipe slopes, embankment slopes and riser heights. This does not apply to permanent structures, which must have an increase of 15% in the seepage length.

The first step in designing anti-seep collars is to determine the length of pipe within the saturated zone of the embankment. This can be done graphically or by the following equation, assuming that the upstream slope of the embankment intersects the invert of the pipe at its upstream end. (See embankment-invert intersection on the drawing below:

$$L_s = y\ (z + 4)\ \left[1 + \frac{\text{pipe slope}}{0.25\text{-pipe slope}}\right]$$

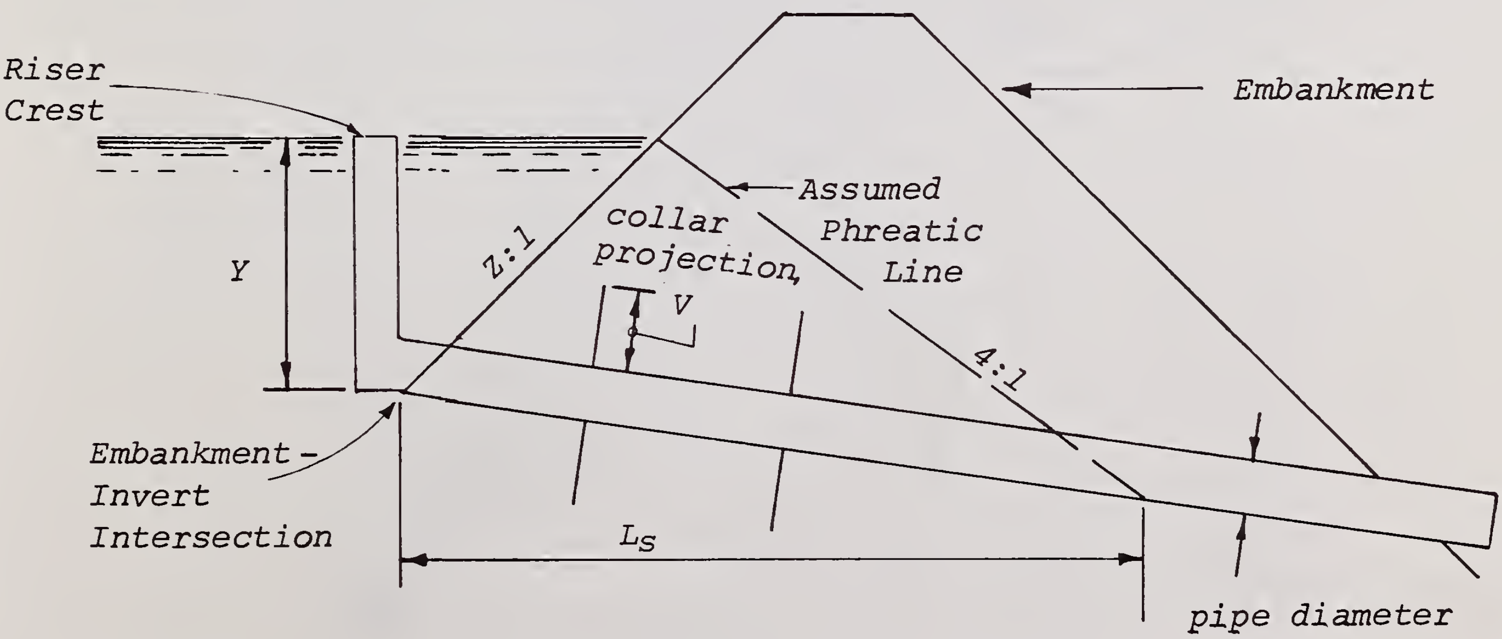
where: L_s = length of pipe in the saturated zone (ft.)

y = distance in feet from upstream invert of pipe to highest normal water level expected to occur during the life of the structure, usually the top of the riser.

z = slope of upstream embankment as a ratio of z ft. horizontal to one ft. vertical.

pipe slope = slope of pipe in feet per foot.

This procedure is based on the approximation of the phreatic line as shown in the drawing below:



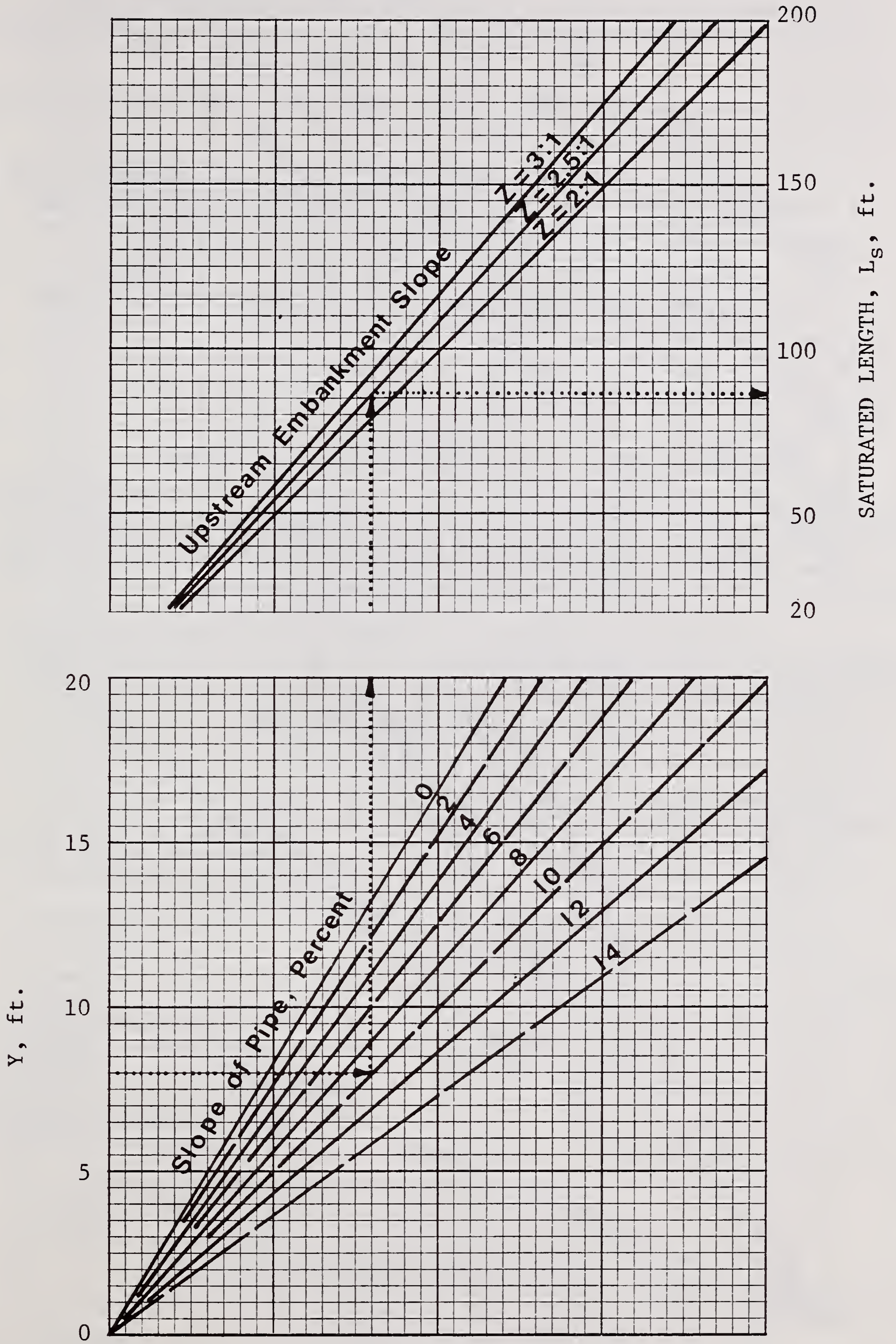
The solution to this equation is given by the chart on the following page for a range of sediment basin configurations. The anti-seep collar size can then be found from the chart on the succeeding page.

Example - Given: y = 8 ft., embankment slope = 2.5:1, pipe slope = 10%, pipe diameter = 36".

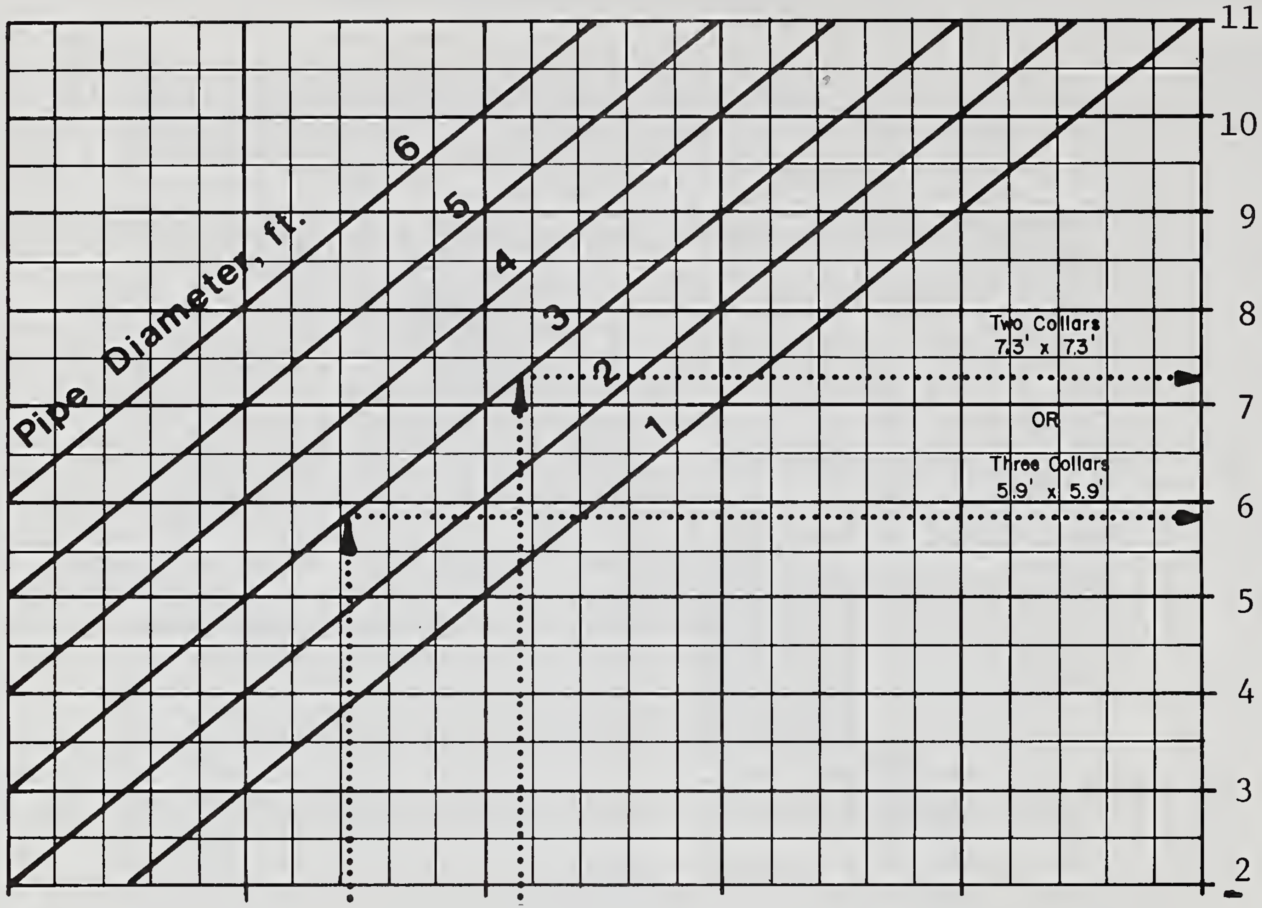
Find: number and size of anti-seep collars.

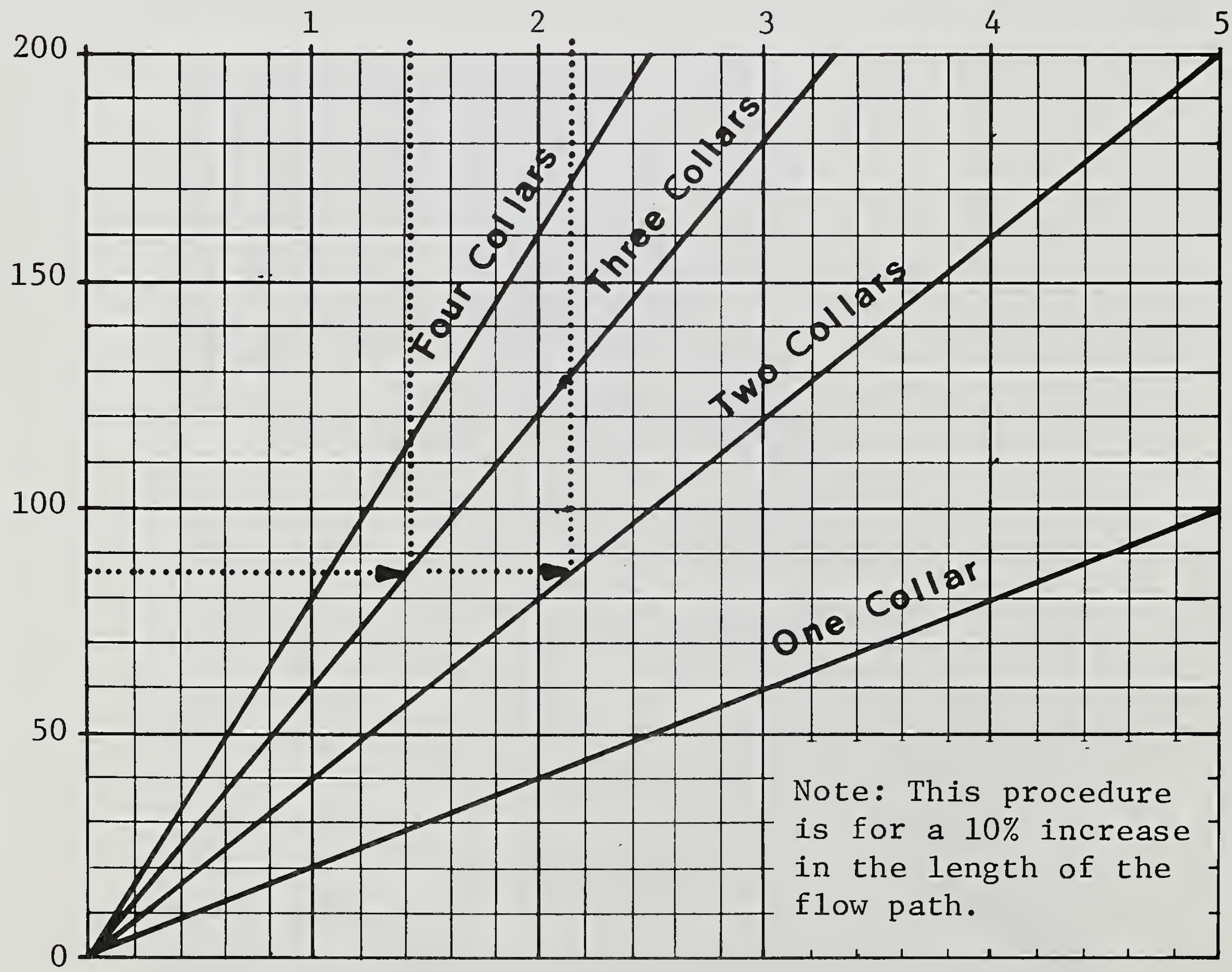
On page A-19.23 of this Appendix, read saturated length, L_s = 87 ft. On page A-19.24 for two collars, the size would be 7.3', and for three collars, 5.9'. Select the two collars since they would be less expensive and easier to install. Collar sizes should be given in feet and inches, therefore, use 2 collars 7'-4" x 7'-4". From page A-19.24 the projection is 2.15'. Therefore, maximum collar spacing is (14) (2.15) = 30.1 ft.

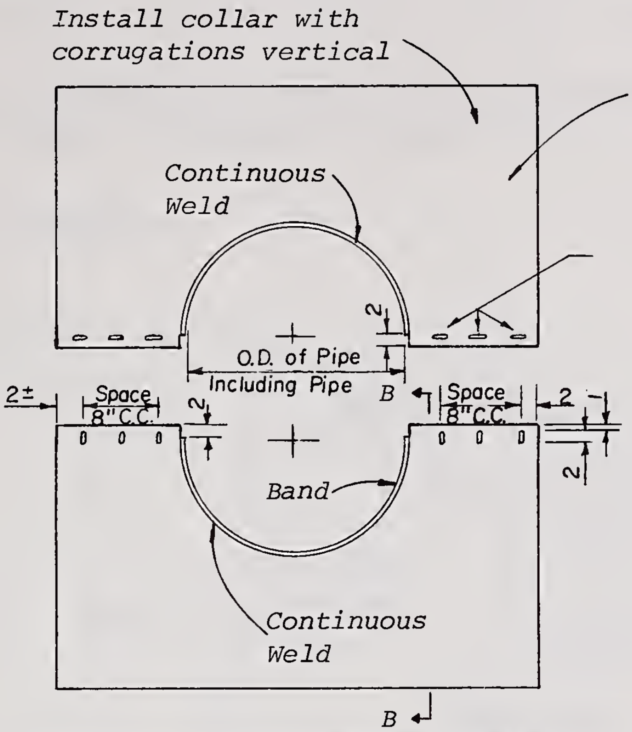
PIPE LENGTH IN SATURATED ZONE



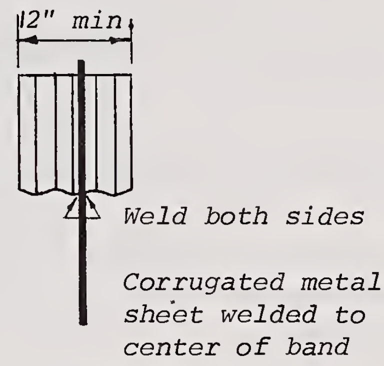
ANTI-SEEP COLLAR DESIGN







ELEVATION OF UNASSEMBLED COLLAR

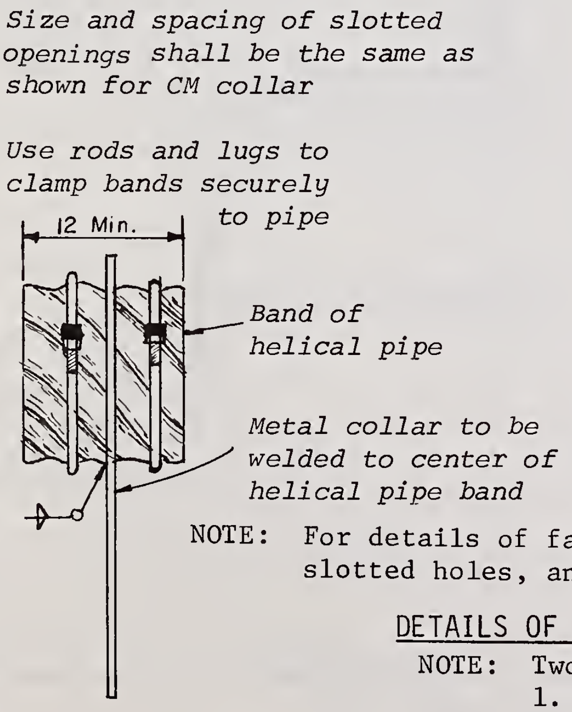


SECTION B-B

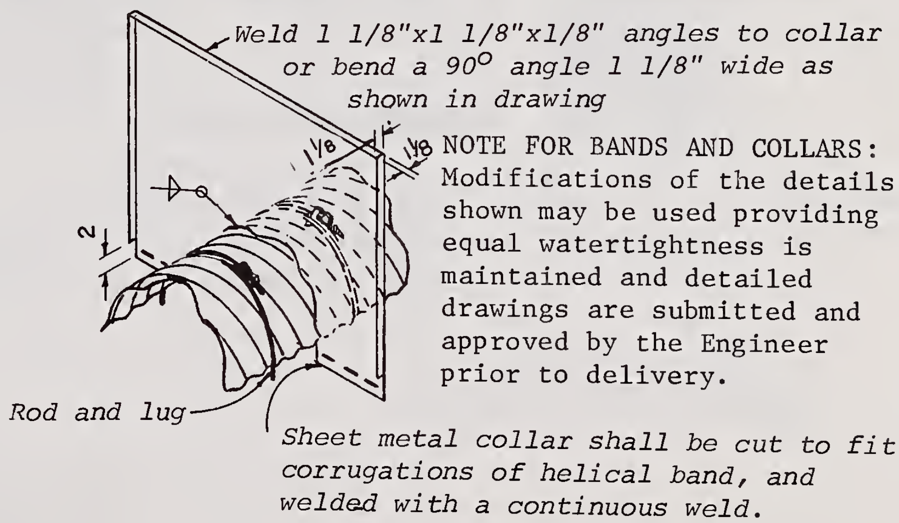
NOTES FOR COLLARS:

1. All materials to be in accordance with construction and construction material specifications.
2. When specified on the plans, coating of collars shall be in accordance with construction and construction material specifications.
3. Unassembled collars shall be marked by painting or tagging to identify matching pairs.
4. The lap between the two half sections and between the pipe and connecting band shall be caulked with asphalt mastic at time of installation.
5. Each collar shall be furnished with two 1/2" diameter rods with standard tank lugs for connecting collars to pipe.

DETAILS OF CORRUGATED METAL ANTI-SEEP COLLAR



PARTIAL ELEVATION



ISOMETRIC VIEW

NOTE FOR BANDS AND COLLARS: Modifications of the details shown may be used providing equal watertightness is maintained and detailed drawings are submitted and approved by the Engineer prior to delivery.

NOTE: For details of fabrication dimensions, minimum gages, slotted holes, and notes, see detail above.

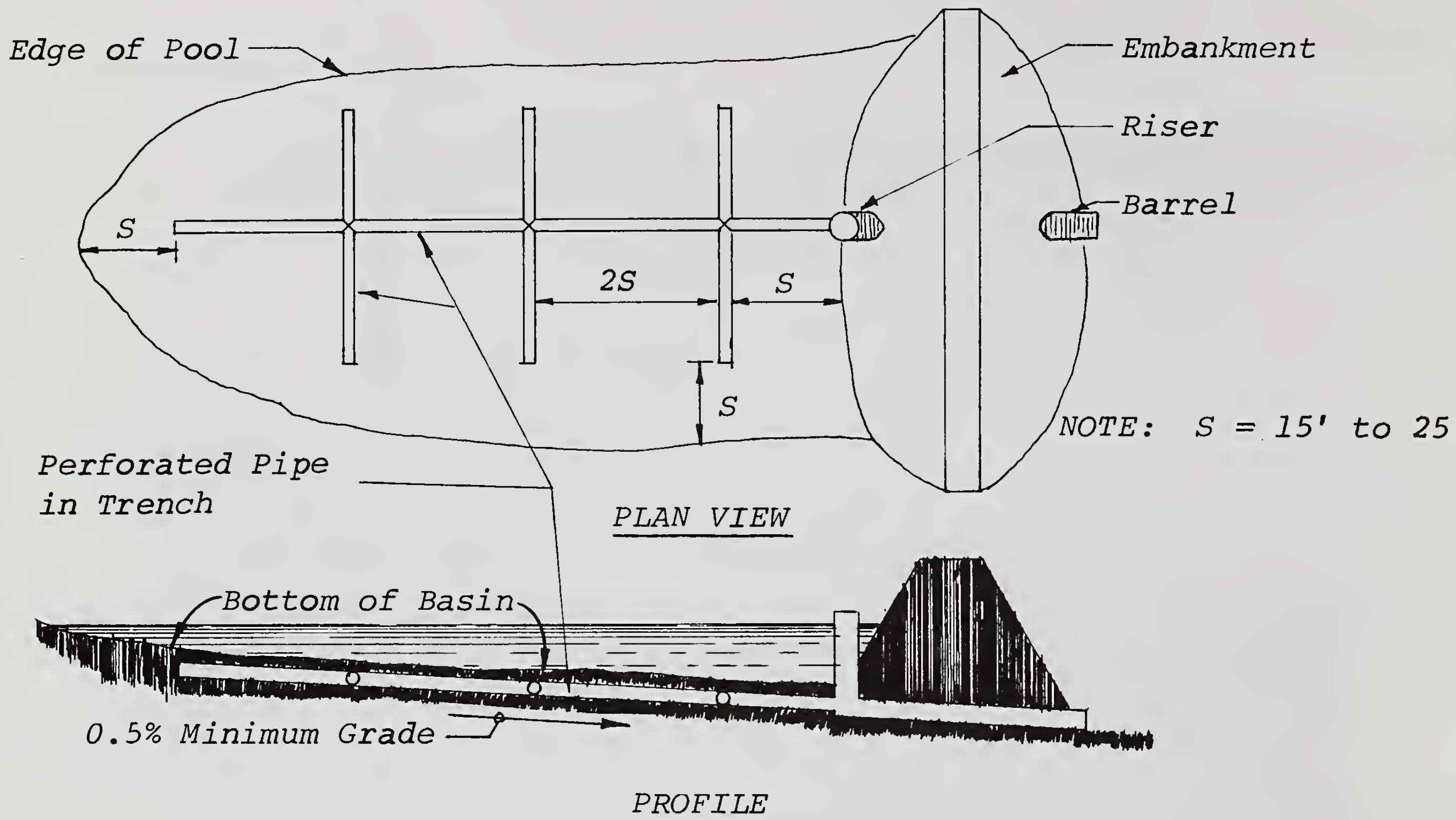
DETAILS OF HELICAL PIPE ANTI-SEEP COLLAR

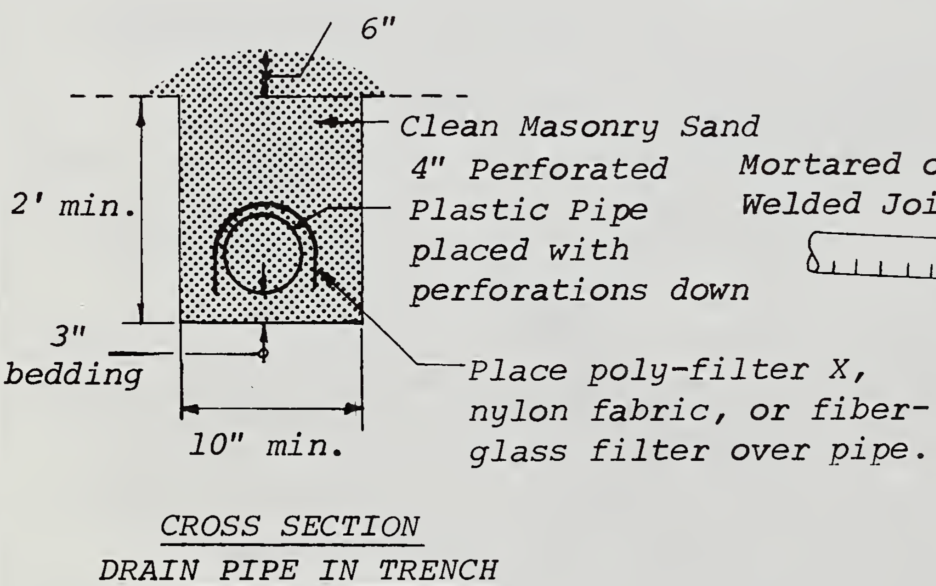
NOTE: Two other types of anti-seep collars are:

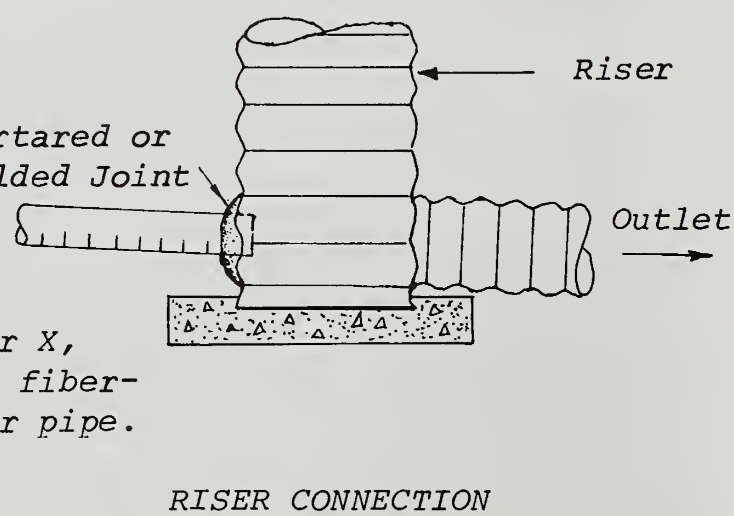
1. Corrugated metal, similar to upper detail, except shop welded to a short (4 ft.) section of the pipe and connected with connecting bands to the pipe.
2. Concrete, six inches thick formed around the pipe with #3 rebar spaced 15" horizontally and vertically.

Ref: Engr. Field Manual

DEWATERING SEDIMENT BASIN WITH SUBSURFACE DRAIN







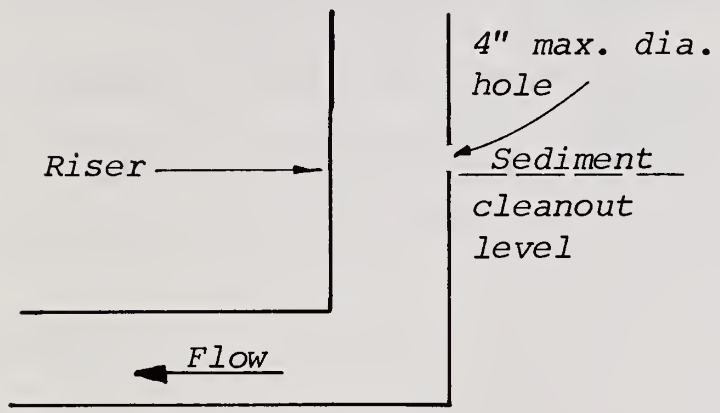
U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE College Park, Md.	DEWATERING SEDIMENT BASIN WITH SUBSURFACE DRAIN	

METHODS OF DEWATERING SEDIMENT BASIN DETENTION POOLS

The dewatering methods shown here are inexpensive and operate automatically. Other methods, such as pumping, may also be used.

METHOD	COMMENTS

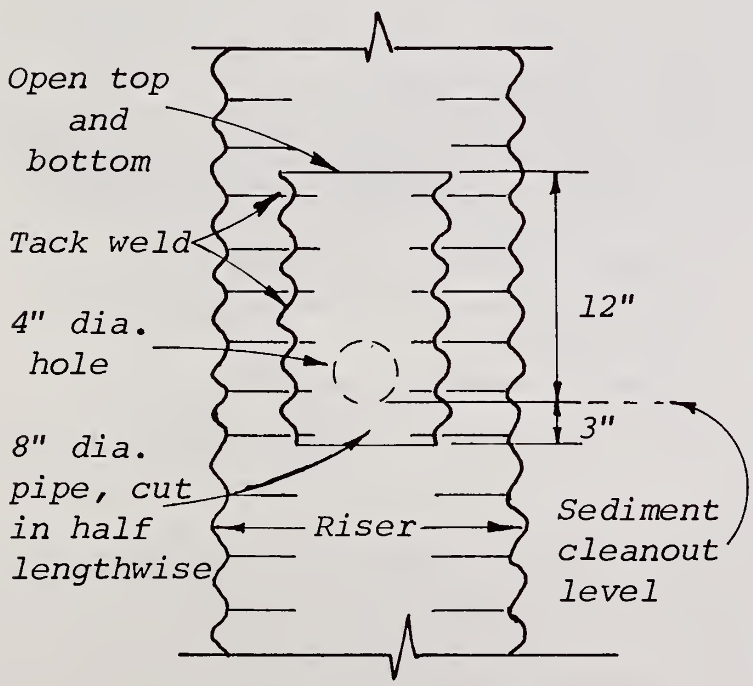
A.



CROSS-SECTION

Easy to construct
May clog with trash
Non-skimming
Capable of draining down to sediment clean-out level
Passes base flow without storage of water

B. Same as "A" except for skimming device, detailed below:

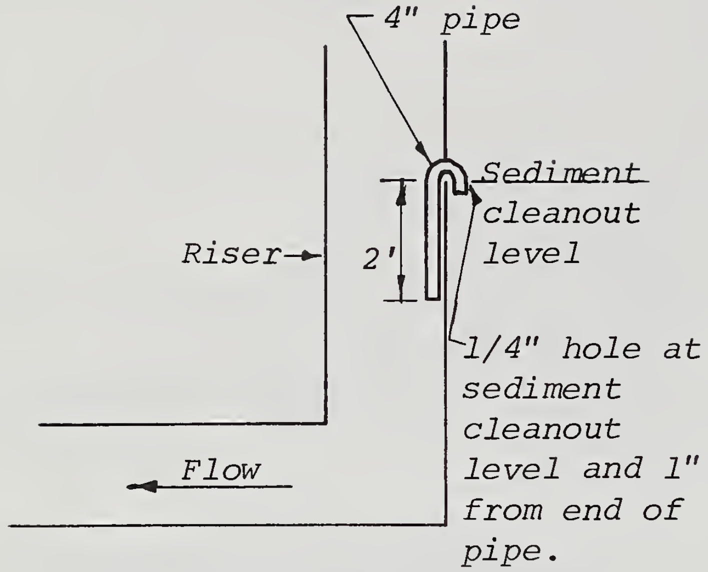


ELEVATION

Efficient skimmer
Non-clogging
Fairly easy to construct
Capable of draining down to sediment cleanout level
Passes base flow without storage of water

METHOD | COMMENTS

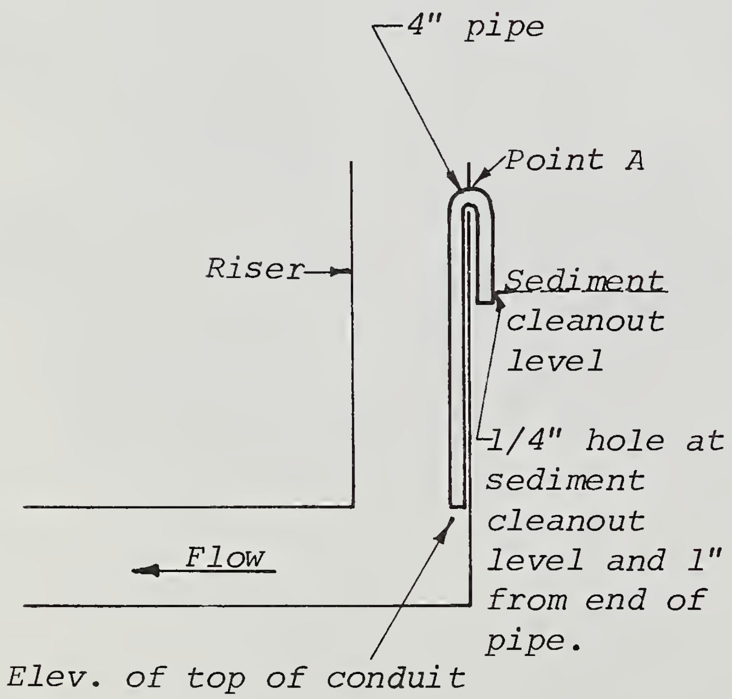
C.



CROSS-SECTION

Efficient skimmer
Capable of always draining down to sediment cleanout level
Passes base flow without storage of water
Higher discharge rate than "A" or "B".

D.



CROSS-SECTION

Efficient skimmer
Water must inundate point A to prime siphon. Therefore, small storms or low base flow rates will not prime siphon and drain pool.
Passes base flow (but with storage of water)
Higher discharge rate than "C"

PROCEDURE FOR DETERMINING OR ALTERING SEDIMENT BASIN SHAPE

As specified in the Standard & Specification, the pool area at the elevation of crest of the principal spillway shall have a length to width ratio of at least 2.0 to 1. The purpose of this requirement is to minimize the "short-circuiting" effect of the sediment laden inflow to the riser and thereby increase the effectiveness of the sediment basin. The purpose of this procedure is to prescribe the parameters, procedures and methods of determining and modifying the shape of the basin.

The length of the flow path (L) is the distance from the point of inflow to the riser (outflow point). The point of inflow is the point that the stream enters the normal pool (pool level at the riser crest elevation). The pool area (A) is the area of the normal pool. The effective width (W_e) is found by the equation:

$$W_e = \frac{A}{L}$$

and L:W ration $= \frac{L}{W_e}$

In the event there is more than one inflow point, any inflow point which conveys more than 30 percent of the total peak inflow rate shall meet the length-width ratio criteria.

The required basin shape may be obtained by proper site selection, by excavation or by constructing a baffle in the basin. The purpose of the baffle is to increase the effective flow length from the inflow point to the riser. Baffles shall be placed mid-way between the inflow point and the riser. The baffle length shall be as required to provide the minimum 2:1 length-width ratio. The effective length (L_e) shall be the shortest distance the water must flow from the inflow point around the end of the baffle to the outflow point. Then:

$$W_e = \frac{A}{L_e}$$

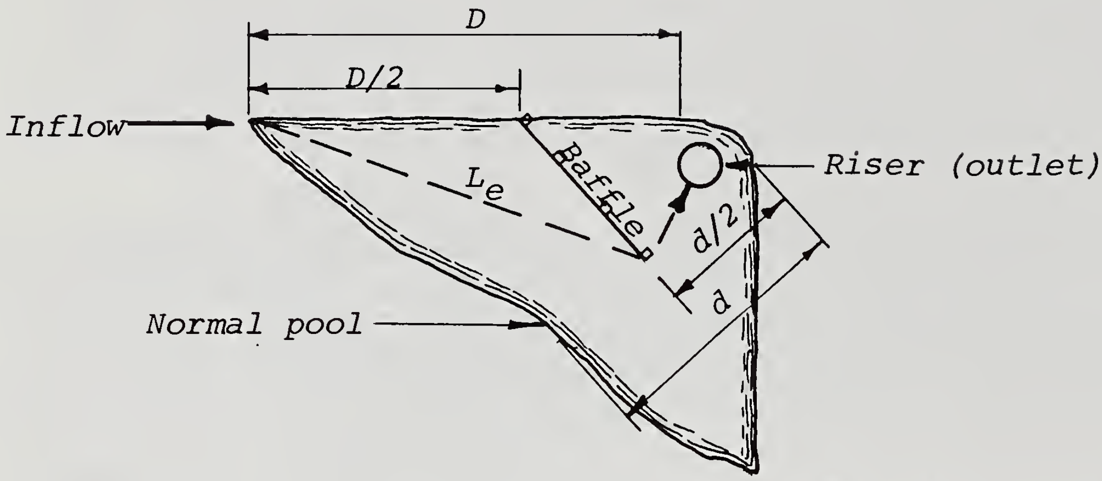
and L:W ratio $= \frac{L_e}{W_e}$

Three examples are shown on the following page. Note that for the special case in example C the water is allowed to go around both ends of the baffle and the effective length, $L_e = L_1 + L_2$. Otherwise, the length-width ratio computations are the same as shown above. This special case procedure for computing L_e is allowable only when the two flow paths are equal, i.e., when $L_1 = L_2$. A baffle detail is also shown.

SEDIMENT BASIN BAFFLES

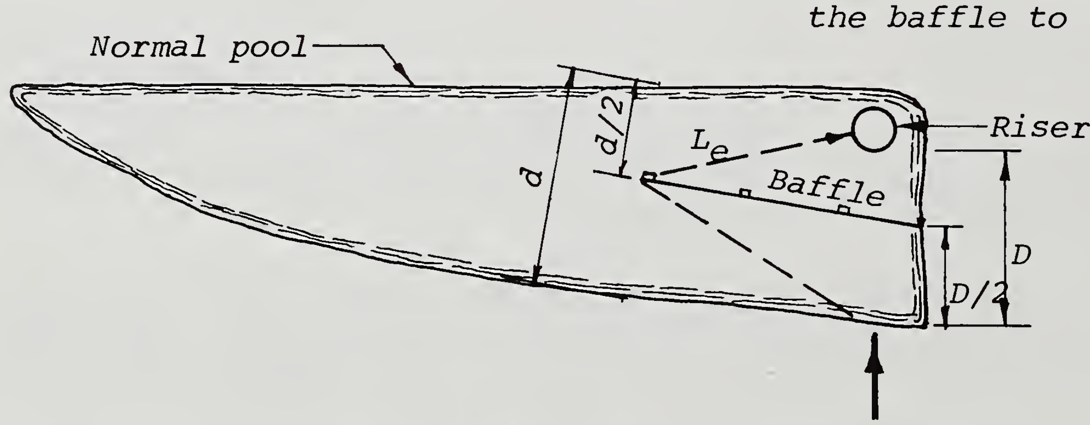
Examples: Plan Views - not to scale

A.

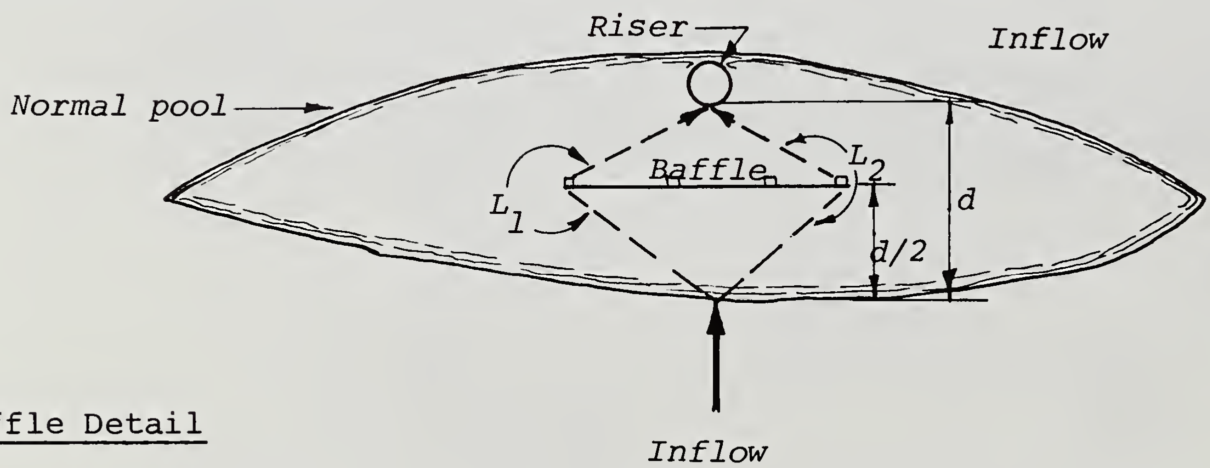


L_e = Total distance from the point of inflow around the baffle to the riser.

B.

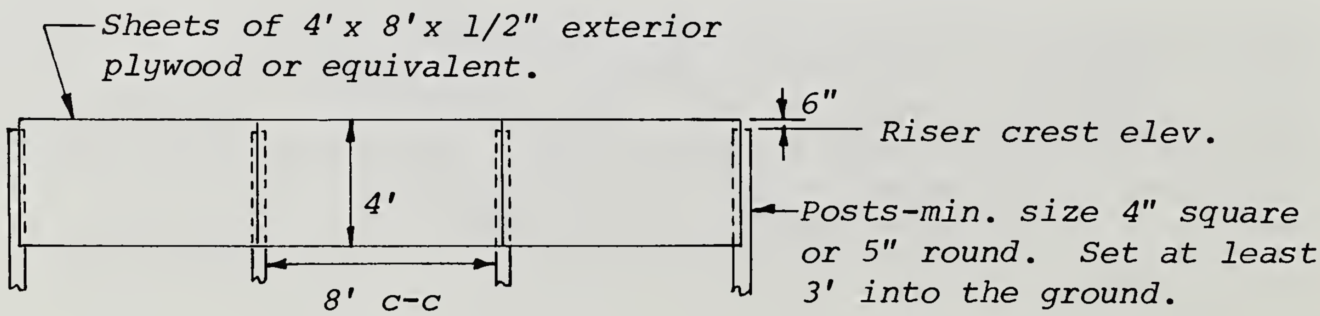


C.



$L_e = L_1 + L_2$

Baffle Detail



ELEVATION

STANDARD AND SPECIFICATIONS

FOR

SEDIMENT TRAP

Definition

A small temporary basin formed by excavation and/or an embankment to intercept sediment laden runoff and to trap and retain the sediment.

PURPOSE

The purpose of a sediment trap is to intercept sediment laden runoff and trap the sediment in order to protect drainageways, properties, and rights-of-way below the sediment trap from sedimentation.

Conditions Where Practice Applies

A sediment trap is usually installed in a drainageway, at a storm drain inlet, or at other points of discharge from a disturbed area.

DESIGN CRITERIA

If any of the design criteria presented here cannot be met see Standard and Specifications for Sediment Basin.

Drainage Area

The drainage area for a sediment trap shall be less than 5 acres.

Location

The sediment trap should be located to obtain the maximum storage benefit from the terrain, for ease of cleanout and disposal of the trapped sediment and to minimize interference with construction activities.

Trap Size

The volume of a sediment trap as measured at the elevation of the crest of the outlet shall be at least 1800 cubic feet per acre of drainage area. The volume of the trap shall be calculated using standard mathematical procedures. The volume of a natural basin may be approximated by the equation; Volume (cu. ft.) = 0.4 x surface area (sq. ft.) x maximum depth (ft.).

Trap Cleanout

Sediment shall be removed and the trap restored to its original dimensions when the sediment has accumulated to 1/2 of the design depth of the trap. Sediment removed from the trap shall be deposited in a suitable area and in such a manner that it will not erode.

Embankment

All embankments for sediment traps shall not exceed 5 feet in height as measured at the low point of the original ground along the centerline of the embankment. Embankments shall have a minimum 4 foot wide top and side slopes of 2:1 or flatter. The embankment shall be compacted by traversing with equipment while it is being constructed.

Excavation

All excavation operations shall be carried out in such a manner that erosion and water pollution shall be minimal. Any excavated portion of sediment trap shall have 2:1 or flatter slopes.

Outlet

There are 4 types of outlets for sediment traps. Each sediment trap is named according to the type of outlet that it has. Each type has different design criteria and will be discussed separately. The outlets shall be designed, constructed and maintained in such a manner that sediment does not leave the trap and that erosion of the outlet does not occur. A trap may have several different outlets with each outlet conveying part of the flow based on the criteria below and the combined outlet capacity shall meet that criteria. For example, a 12 foot earth outlet (adequate for 2 acres) and a 12" pipe outlet (adequate for 1 acre) could be used for a three acre drainage area.

An Earth Outlet Sediment Trap consists of a basin formed by excavation and/or an embankment. The trap has a discharge point over or cut into natural ground. The outlet width (feet) shall be equal to 6 times the drainage area (acres). If an embankment is used the outlet crest shall be at least one foot below the top of the embankment. The outlet shall be free of any restriction to flow. See details for Earth Outlet Sediment Trap on Standard Drawing ST-1.

A Pipe Outlet Sediment Trap consists of a basin formed by an embankment of excavation and an embankment. The outlet for the trap is through a perforated riser and a pipe through the embankment. The outlet pipe and riser shall be made of corrugated metal. The riser diameter shall be of the same or larger diameter than the pipe. The top of the embankment shall be at least 1-1/2 feet above the crest of the riser. At least the top 2/3 of the riser shall be perforated with 1/2" diameter holes spaced 8 inches vertically and 10-12 inches horizontally. All pipe connections shall be watertight.

Select pipe diameter from following table:

Min. Pipe Diameter	Max. Drainage Area
12"	1
18"	2
21"	3
24"	4
30"	5

See details for Pipe Outlet Sediment Trap on Standard Drawing ST-2.

A Stone Outlet Sediment Trap consists of a basin formed by an embankment or excavation and an embankment. The outlet for the trap is over a level stone section. The stone outlet for a sediment trap differs from that for a stone outlet structure because of the intentional ponding of water behind the stone. To provide for a ponding area a relatively impervious core (e.g. - timber, concrete block or straw bales) is placed in the stone. The core shall be covered by 6" of stone.

The minimum length (feet) of the outlet shall be equal to 6 times the drainage area (acres). The crest of the outlet (top of stone) shall be at least 1 foot below the top of the embankment. The crushed stone used in the outlet shall meet AASHTO designation M43, Size No. 2 or 24 or its equivelent such as MSHA #2. Gravel meeting the above gradation may be used if crushed stone is not available. See details for Stone Outlet Sediment Trap on Standard Drawing ST-3.(8,9)

A Storm Inlet Sediment Trap consists of a basin formed by excavation or natural ground that discharges through an opening in a storm drain inlet structure. This opening can either be the inlet opening or a temporary opening made by omitting bricks or blocks in the inlet.

A yard drain inlet or an inlet in the median strip of a dual highway would use the inlet opening for an outlet. A curb inlet would require a temporary opening. The trap should be out of the roadway so as not to interfere with construction. Placing the trap on the opposite side of the opening and diverting water from the roadway to the trap is one means of doing this. See details for Storm Inlet Sediment Trap on Standard Drawing ST-4.

Sediment Plan Details

There is no standard symbol for a sediment trap. Each trap shall be delineated on the plans in such a manner that it will not be confused with any other features. Each trap on a plan shall have a number and the numbers shall be consecutive. The following information shall be shown for each trap in a summary - table form on the same sheet that the trap is on:

1) type of trap

2) size of outlet

3) trap dimensions

4) embankment height and excavation depth

5) drainage area

CONSTRUCTION SPECIFICATIONS

1. Area under embankment shall be cleared, grubbed, and stripped of any vegetation and root mat. The pool area shall be cleared.

2. The fill material for the embankment shall be free of roots or other woody vegetation as well as oversized stones, rocks, organic material or other objectionable material. The embankment shall be compacted by traversing with equipment while it is being constructed.

3. Sediment shall be removed and trap restored to its original dimensions when the sediment has accumulated to 1/2 the design depth of the trap. Removed sediment shall be deposited in a suitable area and in such a manner that it will not erose.

4. The structure shall be inspected after each rain and repairs made as needed.

5. Construction operations shall be carried out in such a manner that erosion and water pollution are minimized.

6. The structure shall be removed and area stabilized when the remaining drainage area has been properly stabilized.

7. All cut and fill slopes shall be 2:1 or flatter.

8. All pipe joints shall be watertight.

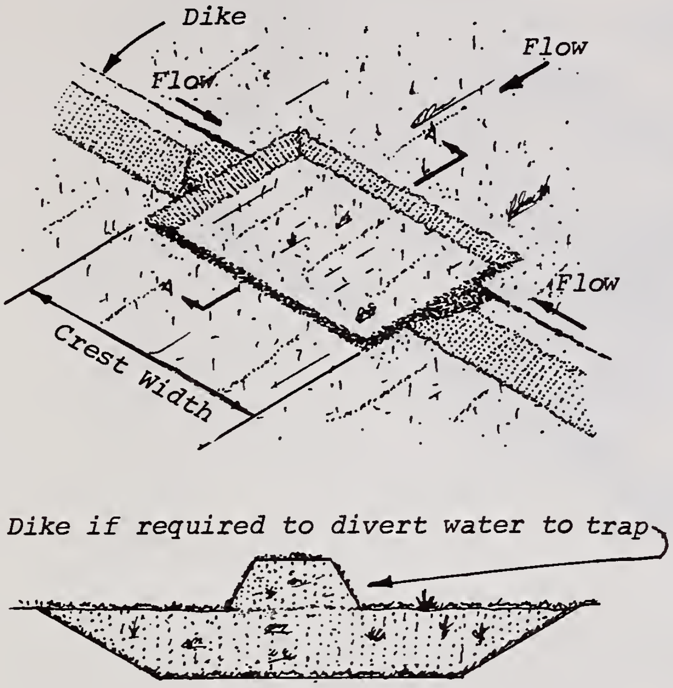
9. At least the top 2/3 of the riser shall be perforated with 1/2-inch diameter holes spaced 8 inches vertically and 10-12 inches horizontally.

10. Fill material around the pipe spillway shall be hand-compacted in 4-inch layers. A minimum of two feet of hand-compacted backfill shall be placed over the pipe spillway before crossing it with construction equipment.

11. Outlet crest elevation shall be at least below the top of the embankment, except for pipe outlets, this shall be at least 1.5 feet.

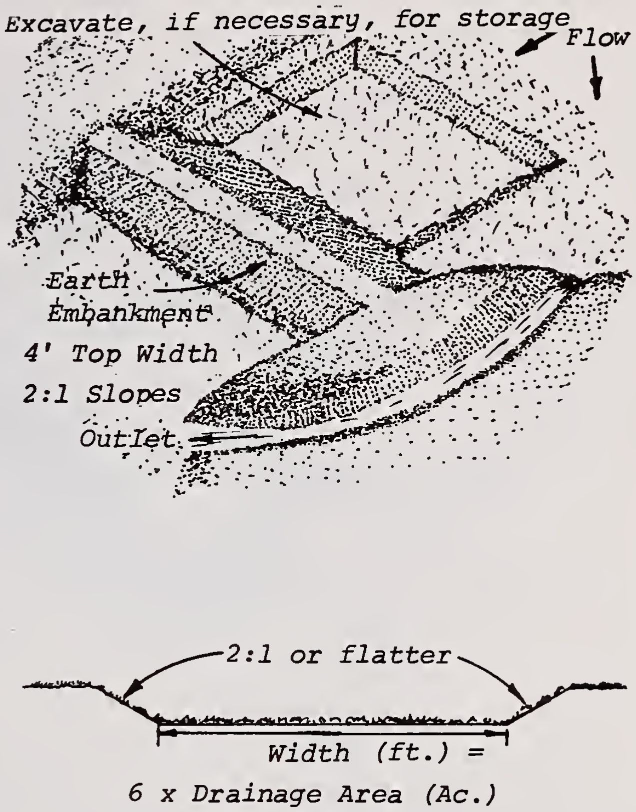
12. The crushed stone used in the outlet shall meet AASHTO designation M43, Size No. 2 or 24 or its equivalent such as MSHA #2. Gravel, meeting the above gradation, may be used if crushed stone is not available. Crusher run is not acceptable.

EARTH OUTLET SEDIMENT TRAP*



SECTION A-A

EXCAVATED EARTH OUTLET SEDIMENT TRAP



OUTLET SECTION

EMBANKMENT EARTH OUTLET SEDIMENT TRAP

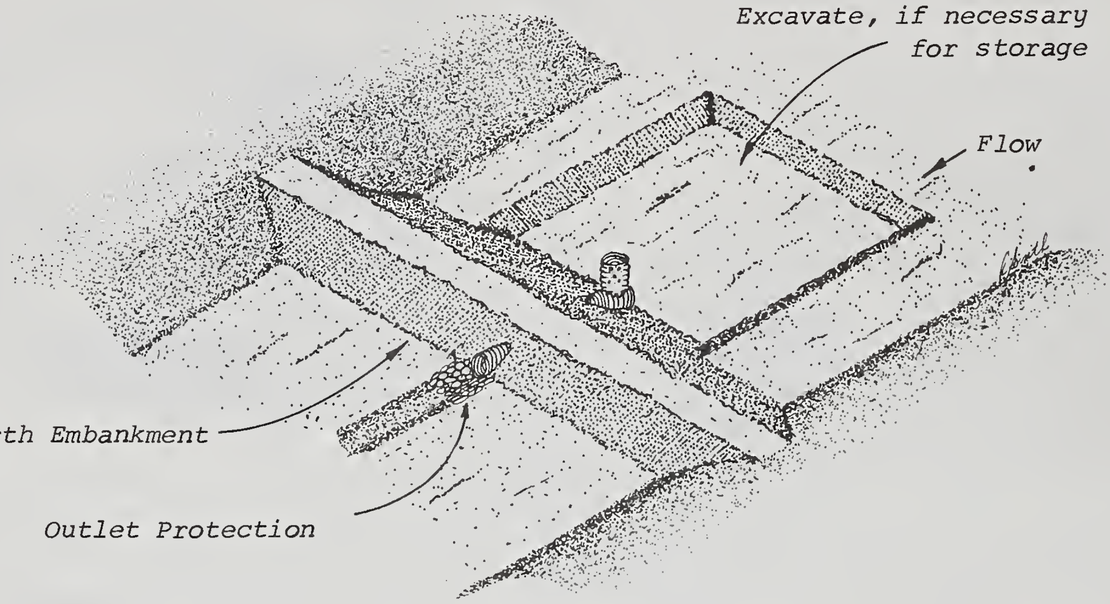
Construction Specifications

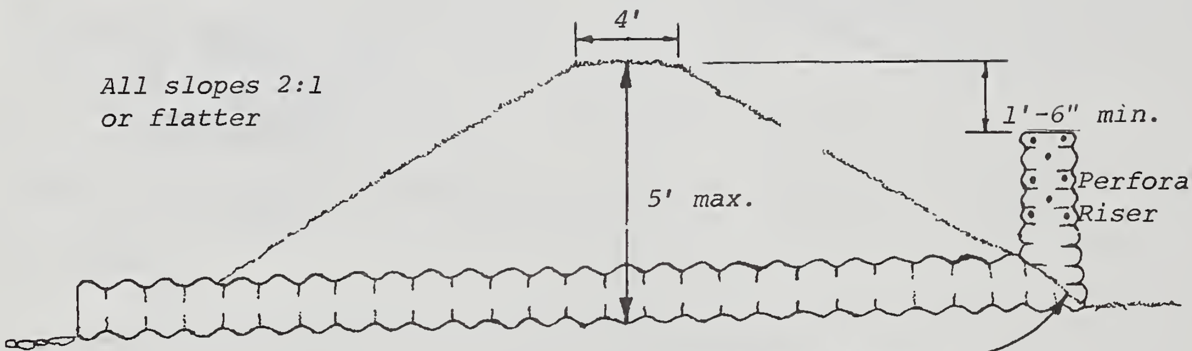
1. Area under embankment shall be cleared, grubbed and stripped of any vegetation and root mat. The pool area shall be cleared.
2. The fill material for the embankment shall be free of roots or other woody vegetation as well as oversized stones, rocks, organic material, or other objectionable material. The embankment shall be compacted by traversing with equipment while it is being constructed.
3. Sediment shall be removed and trap restored to its original dimensions when the sediment has accumulated to 1/2 the design depth of the trap. Removed sediment shall be deposited in a suitable area and in such a manner that it will not erode.
4. The structure shall be inspected after each rain and repairs made as needed.
5. Construction operations shall be carried out in such a manner that erosion and water pollution are minimized.
6. The structure shall be removed and area stabilized when the drainage area has been properly stabilized.
7. All cut and fill slopes shall be 2:1 or flatter.
8. Outlet crest elevation shall be at least one foot below the top of the embankment.

* Drainage area less than 5 acres

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE College Park, Md.	EARTH OUTLET SEDIMENT TRAP	Standard Drawing ST-1

PIPE OUTLET SEDIMENT TRAP*





EMBANKMENT SECTION THRU RISER

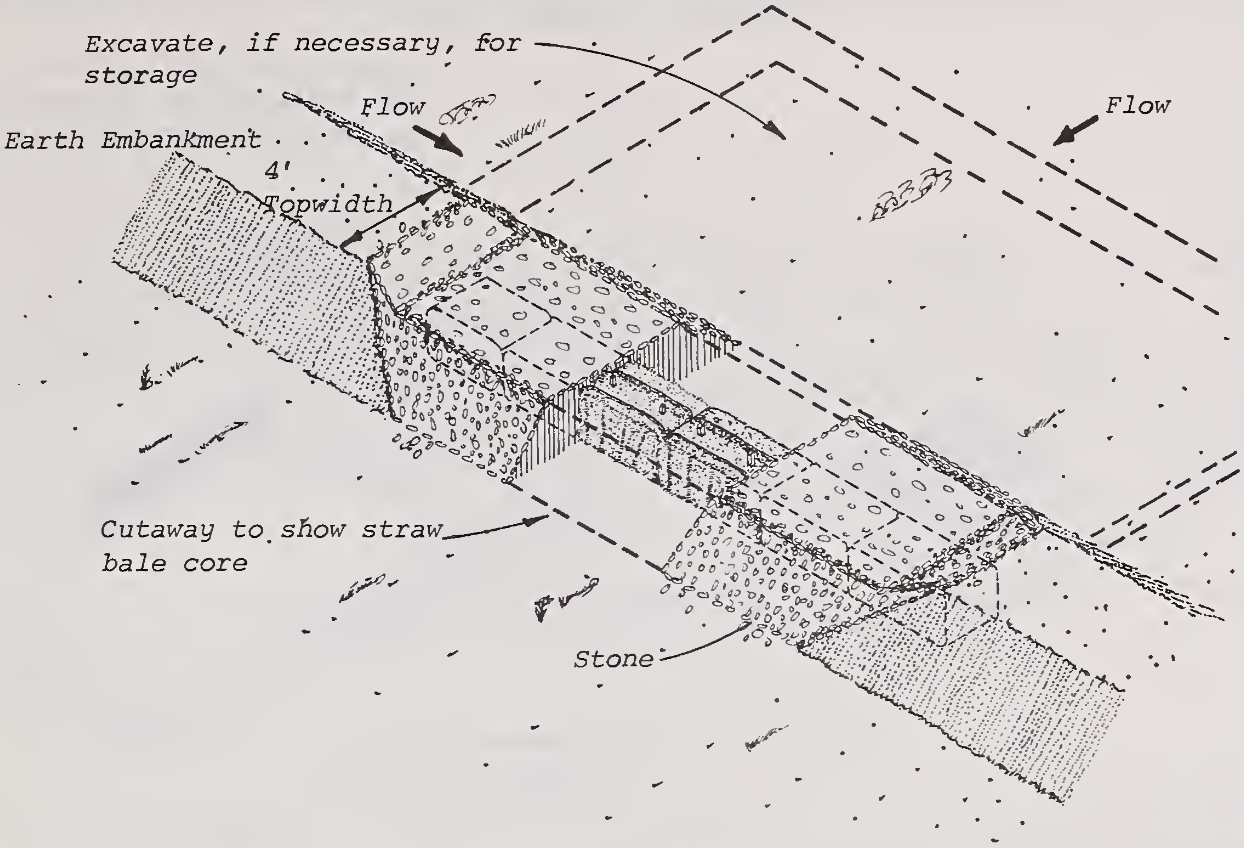
Construction Specifications

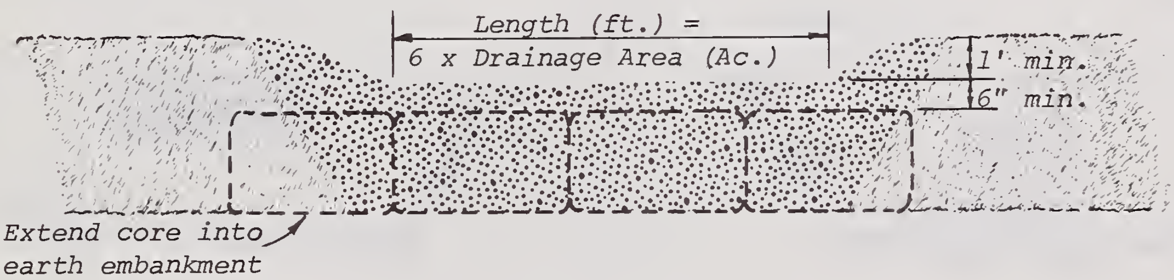
1. Area under embankment shall be cleared, grubbed and stripped of any vegetation and root mat. The pool area shall be cleared.
2. The fill material for the embankment shall be free of roots or other woody vegetation as well as oversized stones, rocks, organic material, or other objectionable material. The embankment shall be compacted by traversing with equipment while it is being constructed.
3. Sediment shall be removed and trap restored to its original dimensions when the sediment has accumulated to 1/2 the design depth of the trap. Removed sediment shall be deposited in a suitable area and in such a manner that it will not erode.
4. The structure shall be inspected after each rain and repairs made as needed.
5. Construction operations shall be carried out in such a manner that erosion and water pollution is minimized.
6. The structure shall be removed and area stabilized when the drainage area has been properly stabilized.
7. All cut and fill slopes shall be 2:1 or flatter.
8. All pipe connections shall be watertight.
9. At least the top 2/3 of the riser shall be perforated with 1/2-inch diameter holes spaced 8 inches vertically and 10 - 12 inches horizontally.
10. Fill material around the pipe spillway shall be hand compacted in 4-inch layers. A minimum of two feet of hand-compacted backfill shall be placed over the pipe spillway before crossing it with construction equipment.

* Drainage area less than 5 acres.

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE College Park, Md.	PIPE OUTLET SEDIMENT TRAP	Standard Drawing ST-2

STONE OUTLET SEDIMENT TRAP*





ELEVATION

NOTE - Drawings show straw bales used for core. Bales are anchored as per Standard and Specifications for Straw Bale Dike. Other materials (e.g., timber or concrete block) may also be used for core. Firmly anchor all core material to ground.

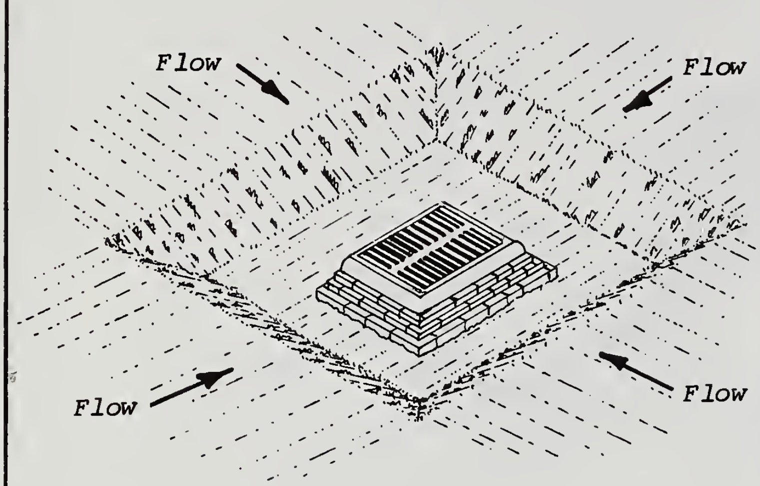
Construction Specifications

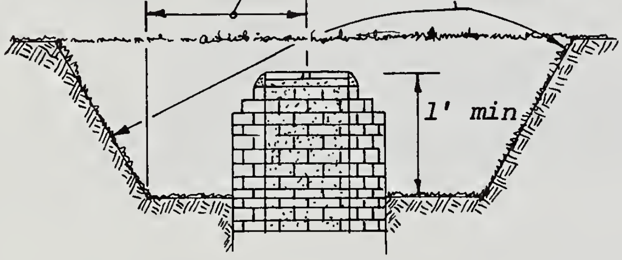
1. Area under embankment shall be cleared, grubbed and stripped of any vegetation and root mat. The pool area shall be cleared.
2. The fill material for the embankment shall be free of roots or other woody vegetation as well as over sized stones, rocks, organic material or other objectionable material. The embankment shall be compacted by traversing with equipment while it is being constructed.
3. Sediment shall be removed and trap restored to its original dimensions when the sediment has accumulated to 1/2 the design depth of the trap. Removed sediment shall be deposited in a suitable area and in such a manner that it will not erode.
4. The structure shall be inspected after each rain and repairs made as needed.
5. Construction operations shall be carried out in such a manner that erosion and water pollution is minimized.
6. The structure shall be removed and the area stabilized when the drainage area has been properly stabilized.
7. All cut and fill slopes shall be 2:1 or flatter.
8. The crushed stone used in the outlet shall meet AASHTO designation M43, Size No. 2 or 24 or its equivalent such as MSHA No. 2. Gravel, meeting the above gradation, may be used if crushed stone is not available. Crusher run is not acceptable.

* Drainage area less than 5 acres.

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE College Park, Md.	STONE OUTLET SEDIMENT TRAP	Standard Drawing ST-3

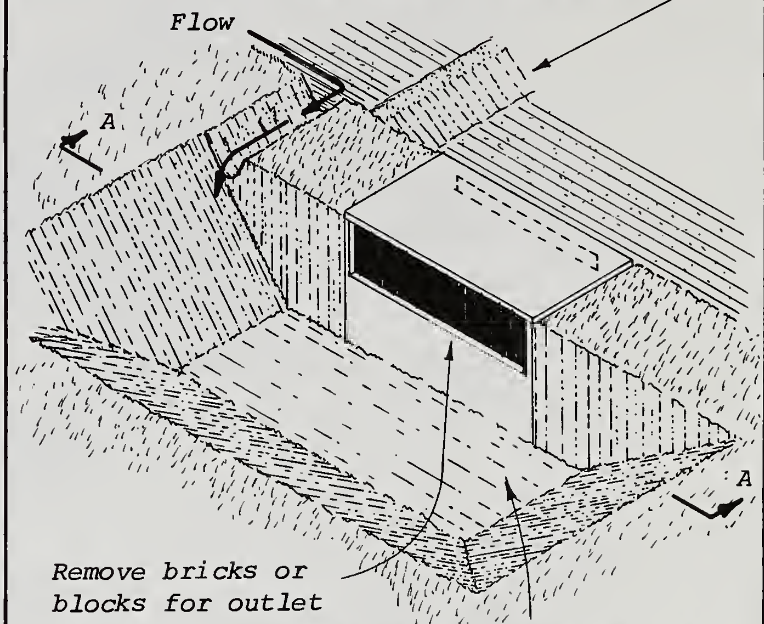
STORM INLET SEDIMENT TRAP*

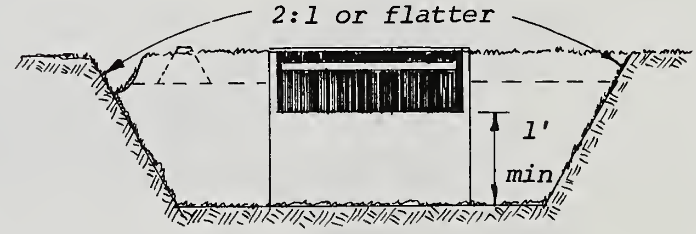




CROSS-SECTION

YARD DRAIN





SECTION A-A

CURB DRAIN

NOTE: Where curb is in place, provide a 1 ft. wide opening in the curb or use a sandbag dam to force water over the curb to the trap.

CONSTRUCTION SPECIFICATIONS

1. Sediment shall be removed and trap restored to its original dimensions when the sediment has accumulated to 1/2 the design depth of the trap. Removed sediment shall be deposited in a suitable area and in such a manner that it will not erode.
2. The structure shall be inspected after each rain and repairs made as needed.
3. Construction operations shall be carried out in such a manner that erosion and water pollution shall be minimized.
4. The sediment trap shall be removed and area stabilized when the remaining drainage area has been properly stabilized.
5. All cut and fill slopes shall be 2:1 or flatter.

*Drainage area less than 5 acres.

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE College Park, Md.	STORM INLET SEDIMENT TRAP	Standard Drawing ST-4

SECTION II

STANDARDS AND SPECIFICATIONS

FOR

PERMANENT STRUCTURAL PRACTICES

STANDARD AND SPECIFICATIONS

FOR

DIVERSION

Definition

A drainageway of parabolic or trapezoidal cross-section with a supporting ridge on the lower side that is constructed across the slope.

Purpose

The purpose of a diversion is to intercept and convey runoff to stable outlets at non-erosive velocities.

Conditions Where Practice Applies

Diversions are used where:

1. Runoff from higher areas is or has potential for damaging property, causing erosion, or interfering with or preventing the establishment of vegetation on lower areas.

2. Surface and/or shallow subsurface flow is damaging sloping upland.

3. The length of slopes needs to be reduced so that soil loss will be reduced to a minimum.

Diversions are only applicable below stabilized or protected areas. Avoid establishment on slopes greater than fifteen percent. Diversions should be used with caution on soils subject to slippage. Construction of diversions shall be in compliance with state drainage and water laws.

Design Criteria

Location

Diversion location shall be determined by considering outlet conditions, topography, land use, soil type, length of slope, seep planes (when seepage is a problem), and the development layout.

Capacity

Peak rates of runoff values used in determining the capacity requirements shall be as outlined in Chapter 2, Estimating Runoff, "Engineering Field Manual for Conservation Practices", or by other accepted methods.(14)

The constructed diversion shall have capacity to carry, as a minimum, the peak discharge from a ten-year frequency rainfall event with freeboard of not less than 0.3 foot.

Diversions designed to protect homes, schools, industrial buildings, roads, parking lots, and comparable high risk areas, and those designed to function in connection with other structures, shall have sufficient capacity to carry peak runoff expected from a storm frequency consistent with the hazard involved.

Velocity and Grade

The permissible velocity for the specified method of stabilization will determine the maximum grade. Maximum permissible velocities of flow for the stated conditions of stabilization are shown in the following table:

Maximum Permissible Design Velocities

Cover	Range of Channel Gradient (Percent)	Permissible Velocity (Feet per Second)
Vegetative 1/	0 to 5.0	6
1) Tufcote, Midland and	5.1 to 10.0	5
Coastal bermudagrass 2/	over 10.0	4
2) Reed canarygrass	0 to 5.0	5
Kentucky 31 tall fescue	5.1 to 10.0	4
Kentucky bluegrass	over 10.0	3
3) Red fescue	0 to 5.0	2.5
Redtop		
4) Annuals 3/	0 to 5.0	2.5
Small grain		
(rye, oats, barley, millet)		
Ryegrass		

1/ To be used only below stabilized or protected areas.

2/ Common bermudagrass is a restricted noxious weed in Maryland.

3/ Annuals - Use only as temporary protection until permanent vegetation is established.

Cross-Section

The diversion channel shall be parabolic or trapezoidal in shape. The design procedures for parabolic and trapezoidal channels are in the Appendix.

The diversion shall be designed to have stable side slopes. The side slopes shall not be steeper than 2:1 and shall be flat enough to insure ease of maintenance of the structure and its protective vegetative cover.

The ridge shall have a minimum width of four feet at the design water elevation; a minimum of 0.3-foot freeboard and a reasonable settlement factor shall be provided.

See Standard Drawing D-1 for details.

Outlets

Each diversion shall have a stable outlet. The outlet may be a constructed or natural waterway, a stabilized open channel, grade stabilization structure, etc. In all cases, the outlet must discharge in such a manner as not to cause erosion. Outlets shall be constructed and stabilized prior to the operation of the diversion.

Stabilization

Diversions shall be stabilized in accordance with the appropriate Standard & Specifications for Vegetative Practices.

CONSTRUCTION SPECIFICATIONS

1. All trees, brush, stumps, obstructions, and other objectionable material shall be removed and disposed of so as not to interfere with the proper functioning of the diversion.

2. The diversion shall be excavated or shaped to line, grade, and cross-section as required to meet the criteria specified herein, and free of irregularities which will impede normal flow.

3. Fills shall be compacted as needed to prevent unequal settlement that would cause damage to the completed diversion.

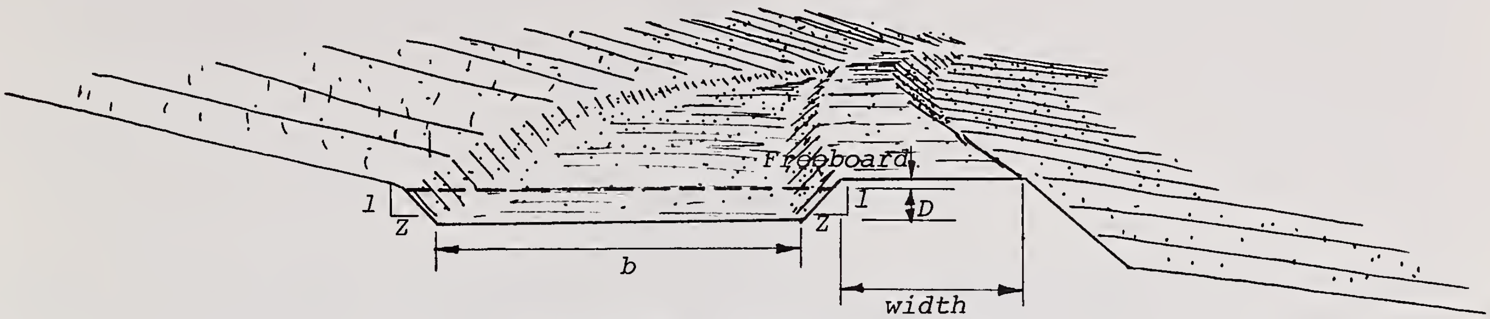
4. All earth removed and not needed in construction shall be spread or disposed of so that it will not interfere with the functioning of the diversion.

5. Stabilization shall be done according to the appropriate Standard and Specifications for Vegetative Practices.

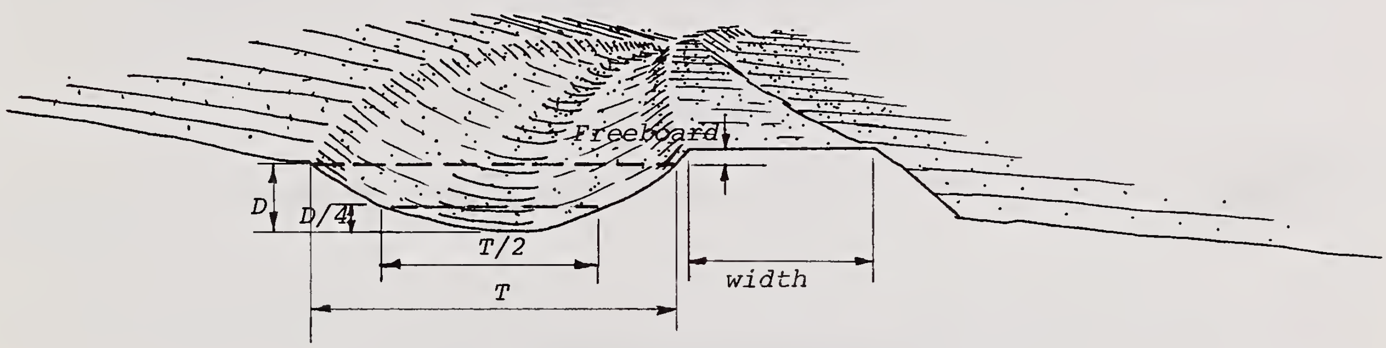
A. For design velocities of less than 3.5 ft./sec., seeding and mulching may be used for the establishment of the vegetation. It is recommended that, when conditions permit, temporary diversions or other means be used to prevent water from entering the diversion during the establishment of the vegetation.

B. For design velocities of more than 3.5 ft./sec., the diversion shall be stabilized with sod, with seeding protected by jute or excelsior matting or with seeding and mulching including temporary diversion of water until the vegetation is established. See Standard & Specification for Protective Materials.

DIVERSION



TRAPEZOIDAL CROSS-SECTION



PARABOLIC CROSS-SECTION

Construction Specifications

1. All trees, brush, stumps, obstructions, and other objectionable material shall be removed and disposed of so as not to interfere with the proper functioning of the diversion.
2. The diversion shall be excavated or shaped to line, grade, and cross section as required to meet the criteria specified herein, and be free of irregularities which will inpede normal flow.
3. Fills shall be compacted as needed to prevent unequal settlement that would cause damage in the completed diversion.
4. All earth removed and not needed in construction shall be spread or disposed of so that it will not interfere with the functioning of the diversion.
5. Stabilization shall be done according to the appropriate Standard and Specifications for Vegetative Practices.
   - A. For design velocities of less than 3.5 ft. per sec., seeding and mulching may be used for the establishment of the vegetation. It is recommended that, when conditions permit, temporary diversions or other means be used to prevent water from entering the diversion during the establishment of the vegetation.
   - B. For design velocities of more than 3.5 ft. per sec., the diversion shall be stabilized with sod, with seeding protected by jute or excelsior matting or with seeding and mulching including temporary diversion of water until the vegetation is established. See the Standard and Specifications for Protective Materials.

Standard Symbol

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE College Park, Md.	DIVERSION	Standard Drawing GW-3

STANDARD AND SPECIFICATIONS

FOR

GRASSED WATERWAY

Definition

A natural or man-made drainageway of parabolic or trapezoidal cross-section that is below adjacent ground level and is stabilized by suitable vegetation. The flow is normally wide and shallow and conveys the runoff down the slope.

Purpose

The purpose of a grassed waterway is to convey runoff without causing damage by erosion.

Conditions Where Practice Applies

Grassed waterways are used where added channel capacity and/or stabilization is required to control erosion resulting from concentrated runoff and where such control can be achieved by this practice alone or in combination with others.

Design Criteria

Capacity

The minimum capacity shall be that required to confine the peak rate of runoff expected from a 10-year frequency rainfall event or a higher frequency corresponding to the hazard involved. This requirement for confinement may be waived on slopes of less than 1 percent where out-of-bank flow will not cause erosion or property damage.

Peak rates of runoff values used in determining the capacity requirements shall be as outlined in Chapter 2, Estimating Runoff, "Engineering Field Manual for Conservation Practices", or by other accepted methods.(14)

Where there is base flow, it shall be handled by a stone center, subsurface drain, or other suitable means since sustained wetness usually prevents adequate vegetative cover. The cross-sectional area of the stone center or subsurface drain to be provided shall be determined by using a flow rate of 0.1 cfs/acre or by actual measurement of the maximum base flow.

Velocity

Maximum permissible velocities of flow for the stated conditions of stabilization are shown in the following table:

Maximum Permissible Design Velocities

No.	Cover	Range of Channel Gradient (percent)	Permissible Velocity (Feet per second)
A.	Vegetative 1/		
	1) Tufcote, Midland and Coastal bermudagrass 2/	0 to 5.0	6
		5.1 to 10.0	5
		over 10.0	4
	2) Reed canarygrass, Kentucky 31 tall fescue, Kentucky bluegrass	0 to 5.0	5
		5.1 to 10.0	4
		over 10.0	3
	3) Red fescue, Redtop	0 to 5.0	2.5
	4) Annuals 3/, Small grain (rye, oats, barley, millet), Ryegrass	0 to 5.0	2.5
B.	Vegetative with Stone Center for base flow		As determined for the vegetative portion from A above.

1/ To be used only below stabilized or protected areas.

2/ Common bermudagrass is a restricted noxious weed in Maryland.

3/ Annuals - Use only as temporary protection until permanent vegetation is established.

Cross-Section

The design water surface elevation of a waterway receiving water from diversions or other tributary channels shall be equal to or less than the design water surface elevation in the diversion or other tributary channels.

The top width of parabolic waterways shall not exceed 30 feet and the bottom width of trapezoidal waterways shall not exceed 15 feet unless multiple or divided waterways, stone center, or other means are provided to control meandering of low flows.

The design procedures for parabolic and trapezoidal channels are in the Appendix.

See Standard Drawings GW-1 and GW-2 for details.

Outlets

Each waterway shall have a stable outlet. The outlet may be another waterway, a stabilized open channel, grade stabilization structure, etc. In all cases, the outlet must discharge in such a manner as not to cause erosion. Outlets shall be constructed and stabilized prior to the operation of the waterway.

Drainage

Subsurface drainage measures shall be provided for sites having high water tables or seepage problems, except where water tolerant vegetation such as Reed canarygrass can be used.

Where there is base flow, a stone center, a subsurface drain or other suitable means shall be required.

Stabilization

Waterways shall be stabilized in accordance with the appropriate Standard & Specifications for Vegetative Practices.

CONSTRUCTION SPECIFICATIONS

1. All trees, brush, stumps, obstructions, and other objectionable material shall be removed and disposed of so as not to interfere with the proper functioning of the waterway.

2. The waterway shall be excavated or shaped to line, grade, and cross-section as required to meet the criteria specified herein, and be free of bank projections or other irregularities which will impede normal flow.

3. Fills shall be compacted as needed to prevent unequal settlement that would cause damage in the completed waterway.

4. All earth removed and not needed in construction shall be spread or disposed of so that it will not interfere with the functioning of the waterway.

5. Stabilization shall be done according to the appropriate Standard and Specifications for Vegetative Practices.

A. For design velocities of less than 3.5 ft./sec., seeding and mulching may be used for the establishment of the vegetation. It is recommended that, when conditions permit, temporary diversions or other means should be used to prevent water from entering the waterway during the establishment of the vegetation.

B. For design velocities of more than 3.5 ft./sec., the waterway shall be stabilized with sod, with seeding protected by jute or excelsior matting or with seeding and mulching including temporary diversion of the water until the vegetation is established.

C. Structural - Vegetative Protection

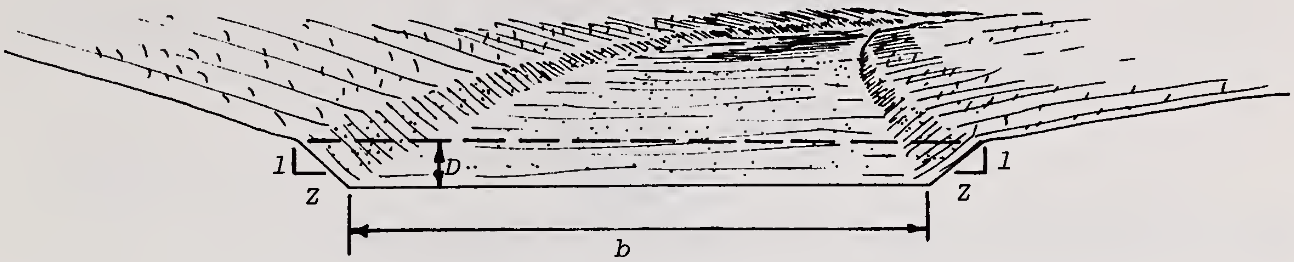
(1) Stone Center for base flow - Stone centers shall be constructed as shown on the Standard Drawing.

The Stone Center portion shall be stabilized with riprap according to Standard and Specifications for Riprap.

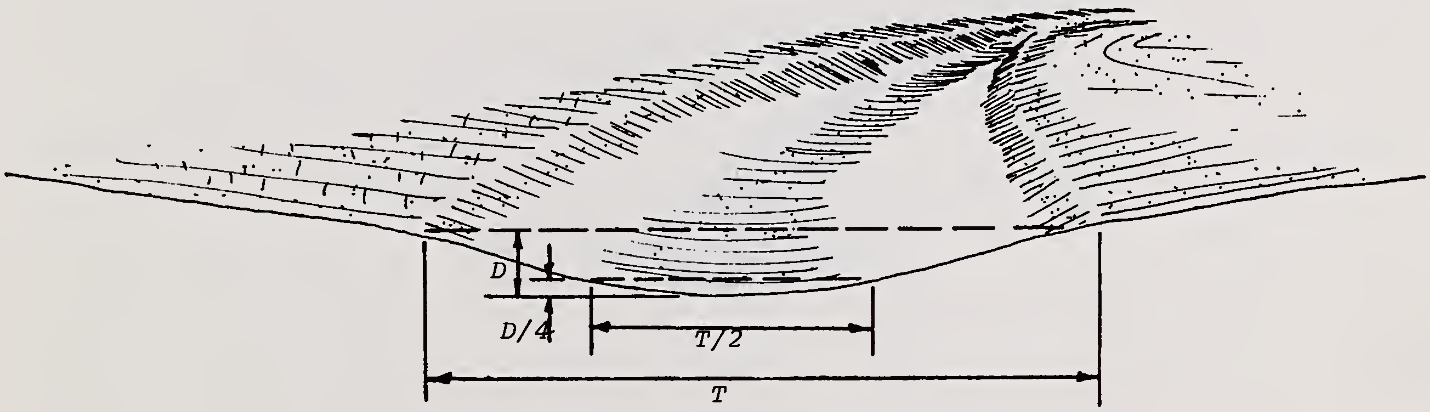
(2) Subsurface drain for base flow shall be constructed as shown on the Standard Drawing and as specified in the Standard and Specifications for Subsurface Drain.

(3) Gabion mattress channel liners may be used for base flow, design flow and for subsurface drainage.

GRASSED WATERWAY



TRAPEZOIDAL CROSS-SECTION



PARABOLIC CROSS-SECTION

Construction Specifications

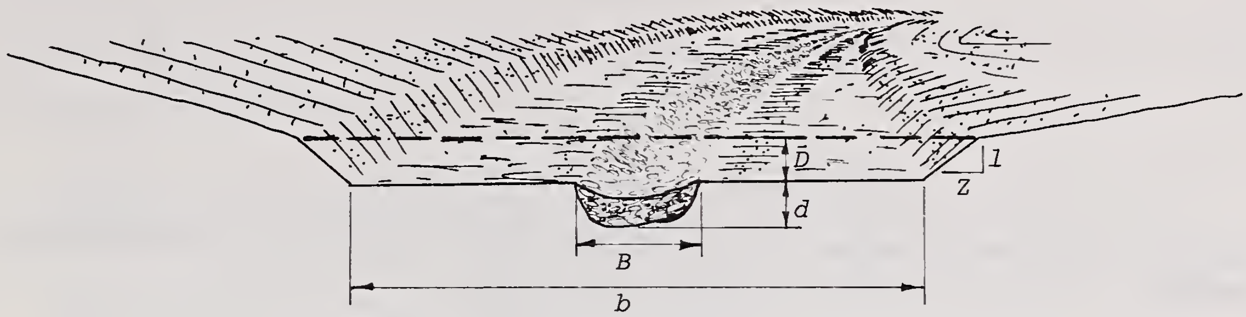
1. All trees, brush, stumps, obstructions, and other objectionable material shall be removed and disposed of so as not to interfere with the proper functioning of the waterway.
2. The waterway shall be excavated or shaped to line, grade, and cross section as required to meet the criteria specified herein, and be free of bank projections or other irregularities which will impede normal flow.
3. Fills shall be compacted as needed to prevent unequal settlement that would cause damage in the complete waterway.
4. All earth removed and not needed in construction shall be spread or disposed of so that it will not interfere with the functioning of the waterway.
5. Stabilization shall be done according to the appropriate Standard and Specifications for Vegetative Practices.
   A. For design velocities of less than 3.5 ft. per sec., seeding and mulching may be used for the establishment of the vegetation. It is recommended that, when conditions permit, temporary diversions or other means should be used to prevent water from entering the waterway during the establishment of the vegetation.
   B. For design velocities of more than 3.5 ft. per sec., the waterway shall be stabilized with sod, with seeding protected by jute or excelsior matting or with seeding and mulching including temporary diversion of the water until the vegetation is established.
   C. Structural - Vegetative Protection
      (1) Subsurface drain for base flow shall be constructed as shown on the Standard Drawing and as specified in the Standard and Specifications for Subsurface Drain.

Standard Symbol 

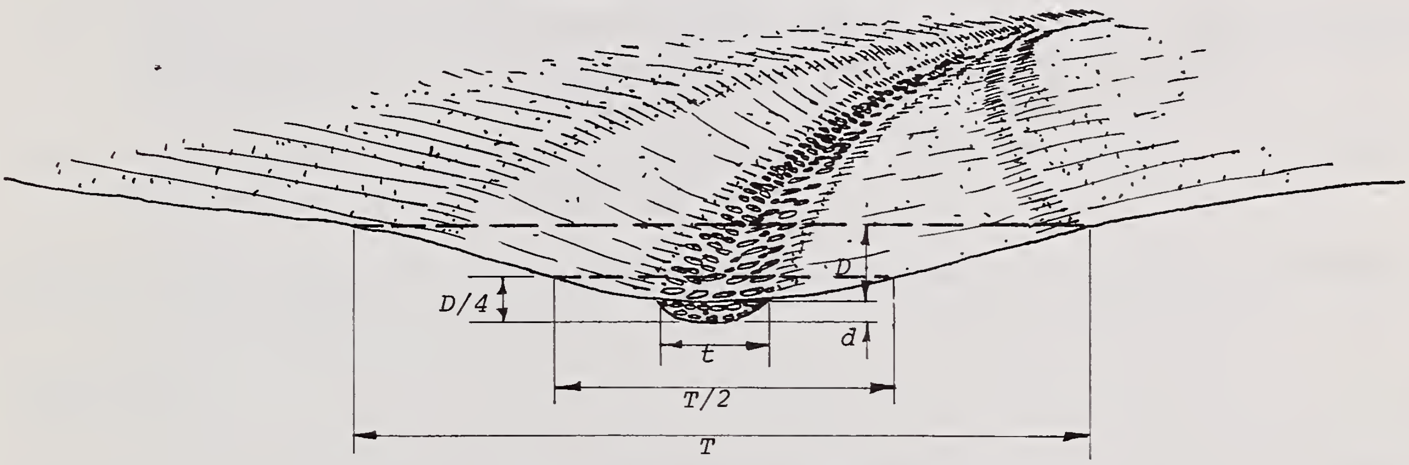
U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE College Park, Md.	GRASSED WATERWAY	Standard Drawing GW-1

See the following page for Standard Drawing GW-2.

GRASSED WATERWAY WITH STONE CENTER



TRAPEZOIDAL CROSS-SECTION



PARABOLIC CROSS-SECTION

Construction Specifications

1. All trees, brush, stumps, obstructions, and other objectionable material shall be removed and disposed of so as not to interfere with the proper functioning of the waterway.
2. The waterway shall be excavated or shaped to line, grade, and cross-section as required to meet the criteria specified herein, and be free of bank projections or other irregularities which will impede normal flow.
3. Fills shall be compacted as needed to prevent unequal settlement that would cause damage in the completed waterway.
4. All earth removed and not needed in construction shall be spread or disposed of so that it will not interfere with the functioning of the waterway.
5. Stabilization shall be done according to the appropriate Standard and Specifications for Vegetative Practices.
   A. For design velocities of less than 3.5 ft.per sec., seeding and mulching may be used for the establishment of the vegetation. It is recommended that, when conditions permit, temporary diversions or other means should be used to prevent water from entering the waterway during the establishment of the vegetation.
   B. For design velocities of more than 3.5 ft. per sec., the waterway shall be stabilized with sod with seeding protected by jute or excelsior matting or with seeding and mulching including temporary diversion of the water until the vegetation is established See the Standard and Specifications for Protective Materials.
   C. Structural - Vegetative Protection
      (1) Stone Center for base flow - Stone centers shall be constructed as shown on the Standard Drawing.
      The base flow portion shall be stabilized with riprap according to Standard and Specifications for Riprap.
      (2) Subsurface drain for base flow shall be constructed as shown on the Standard Drawing and as specified in the Standard and Specifications for Subsurface Drain.
      (3) Gabion mattress channel liners may be used for base flow or design flow.

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE College Park, Md.	GRASSED WATERWAY WITH STONE CENTER	Standard Drawing GW-2

See the following page for Appendix A-36, Waterway and Diversion Design.

WATERWAY AND DIVERSION DESIGN

The following material is provided to assist in the design of grassed waterways and diversions:

1. Graph of the Product of Velocity and Hydraulic Radius versus Mannings "n" for different degrees of vegetal retardance.

2. Table giving classification of vegetal cover based on degree of flow retardance by the vegetation.

3. Parabolic Waterway Design Tables for various grades and velocities for retardance "D", and top width and depth for retardance "C".

4. Trapezoidal Channel Design Tables for various grades, velocities and depths for retardance "C".

The use of these tables and graphs can best be shown by example problems, which are as follows:

Problem 1

Determine the non-erosive velocity and dimensions for stability and capacity for a waterway with parabolic cross-section.

Given:	Runoff	Q = 55 cfs
	Grade	= 5.1 percent
	Vegetative cover	Kentucky bluegrass
	Condition of vegetation	
	Good stand-mowed (3"-4")	= "D" curve retardance
	Good stand-headed (6"-12")	= "C" curve retardance
	Permissible velocity	= 4 ft./sec. (from Pg. 36.02)

Solution: Horizontally opposite 55 cfs on the Parabolic Waterway Design Table for Grade = 5.0 percent (slope table that is nearest 5.1%) and the columns headed V = 4.0 ft./sec., find T = 33 feet and D = 0.8 feet.

Therefore, a waterway with parabolic cross section, a top width of 33 feet, and a depth of 0.8 feet will carry 55 cfs at a maximum velocity of 4 feet per second when the vegetative lining is short (3" to 4" in height). This complies with the requirement for non-erosive velocity when vegetation is short ("D" retardance) and for capacity when vegetation is tall ("C" retardance).

Problem 2

Determine the non-erosive velocity and dimensions for a waterway with trapezoidal cross-section.

Given:	Runoff	Q = 55 cfs
	Grade	= 2 percent
	Side slopes	= 2:1
	Vegetative cover	Kentucky bluegrass
	Condition of vegetation	
	Good stand-headed (6"-12")	= "C" curve retardance
	Permissible velocity	= 5 ft./sec. (from Pg. 36.02)

Solution: Horizontally opposite 55 cfs on the Trapezoidal Channel Design Table for Grade = 2.0 percent, read across to the column for bottom width = 6 feet and read the D = 1.3 feet and V = 4.9 ft./sec.

Therefore, a waterway with trapezoidal cross-section, 2:1 side slope, bottom width of 6 feet, and a depth of 1.3 feet will carry 55 cfs at a maximum velocity of 4.9 feet per second for "C" curve retardance.

Problem 3

Determine the safe velocity and dimensions for a waterway with trapezoidal cross-section that does not fit the Trapezoidal Channel Design Tables.

Given:	Runoff	Q = 55 cfs
	Grade	= 3 percent
	Side slope	= 3:1
	Vegetative cover	Kentucky bluegrass
	Condition of vegetation	
	Good stand-mowed (3"-4") = "D" curve retardance	
	Good stand-headed (6"-12") = "C" curve retardance	
	Permissible velocity = 5 ft./sec. (from Pg. 36.02)	

Solution: The solution is a trial and error process. The first step is to design for stability when the vegetation is short ("D" retardance) and the second step is to design for capacity when the vegetation is tall ("C" retardance).

Step 1 - Stability

$$Q = 55 \text{ cfs.}$$

$$V_{max} = 5 \text{ ft./sec.}$$

$$A = \frac{Q}{V_{max}} = \frac{55}{5} = 11 \text{ sq.ft.}$$

Try Bottom Width = 12 feet

$$A = bd + zd^2$$

$$11 = 12d + 3d^2$$

Note: Solve for d by use of the quadratic equation.

$$ax^2 + bx + c = 0$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$3d^2 + 12d - 11 = 0$$

$$d = \frac{-12 \pm \sqrt{12^2 - 4(3)(-11)}}{2(3)}$$

$$d = \frac{-12 + 16.61}{6} = \frac{4.61}{6}$$

$$d = 0.77 \text{ feet}$$

Hydraulic Radius

$$r = \frac{\text{area}}{\text{wetted perimeter}} = \frac{bd + zd^2}{b + 2d\sqrt{z^2 + 1}}$$

$$r = \frac{12(0.77) + 3\ (0.77^2)}{12 + 2(0.77)\sqrt{3^2 + 1}}$$

$$r = \frac{9.24 + 1.78}{12 + 4.87}$$

$$r = \frac{11.02}{16.87} = 0.65$$

$$Vr = 5(0.65) = 3.25$$

From graph, page A-36.15 for Vr=3.25 and "D" retardance, read n = 0.04

$$V = \frac{1.486}{n}\ r^{2/3}\ s^{1/2}$$

$$= \frac{1.486}{0.04}\ (0.65^{2/3})(.03^{1/2}) = 4.83 \text{ ft./sec.}$$

Okay, but less than V_{max} - try slightly smaller channel.

Try bottom width = 10 feet

$A = bd + zd^2$

$11 = 10d + 3d^2$

$$d = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = 0.87$$

$$r = \frac{bd + zd^2}{b + 2d\sqrt{z^2 + 1}} = 0.71$$

$Vr = 3.55$

$n = 0.040$ from page A-36.15

$V = \frac{1.486}{n} r^{2/3} s^{1/2} = 5.15$ which is greater than V_{max}

Therefore, select design bottom width = 12 feet

Velocity = 4.83 feet/sec. for "D" retardance

$d = 0.8'$

Step 2 - Capacity check using "C" curve retardance. Determine additional depth needed to offset the increase retardance and decreased velocity.

Try d = 0.9 feet

$A = bd + zd^2 = (12)(0.9) + 3(.9^2) = 13.23$

$$r = \frac{A}{P} = \frac{13.23}{b+2d\sqrt{z^2+1}} = \frac{13.23}{12+2(.9)\sqrt{3^2+1}} = 0.75$$

Assume V = 4.4 ft./sec.

$Vr = (4.4)(0.75) = 3.30$

From graph, page A-36.15 for Vr = 3.30 and "C" retardance, read n = 0.046.

$V = \frac{1.486}{0.046} (0.75^{2/3})(.03^{1/2}) = 4.62$ ft./sec.
which is greater than assumed value

Assume V = 4.6 ft./sec.

Vr = (4.6)(0.75) = 3.45

From graph, n = 0.046

$$V = \frac{1.486}{.046} (0.75^{2/3})(.03^{1/2}) = 4.62 \text{ ft./sec.}$$

which is close enough

Therefore, dimensions and velocities are as follows:

Bottom width = 12 feet

Side slopes = 3:1

For "D" retardance - V = 4.83 ft./sec.

d = 0.8 feet

For "C" retardance - V = 4.62 ft./sec.

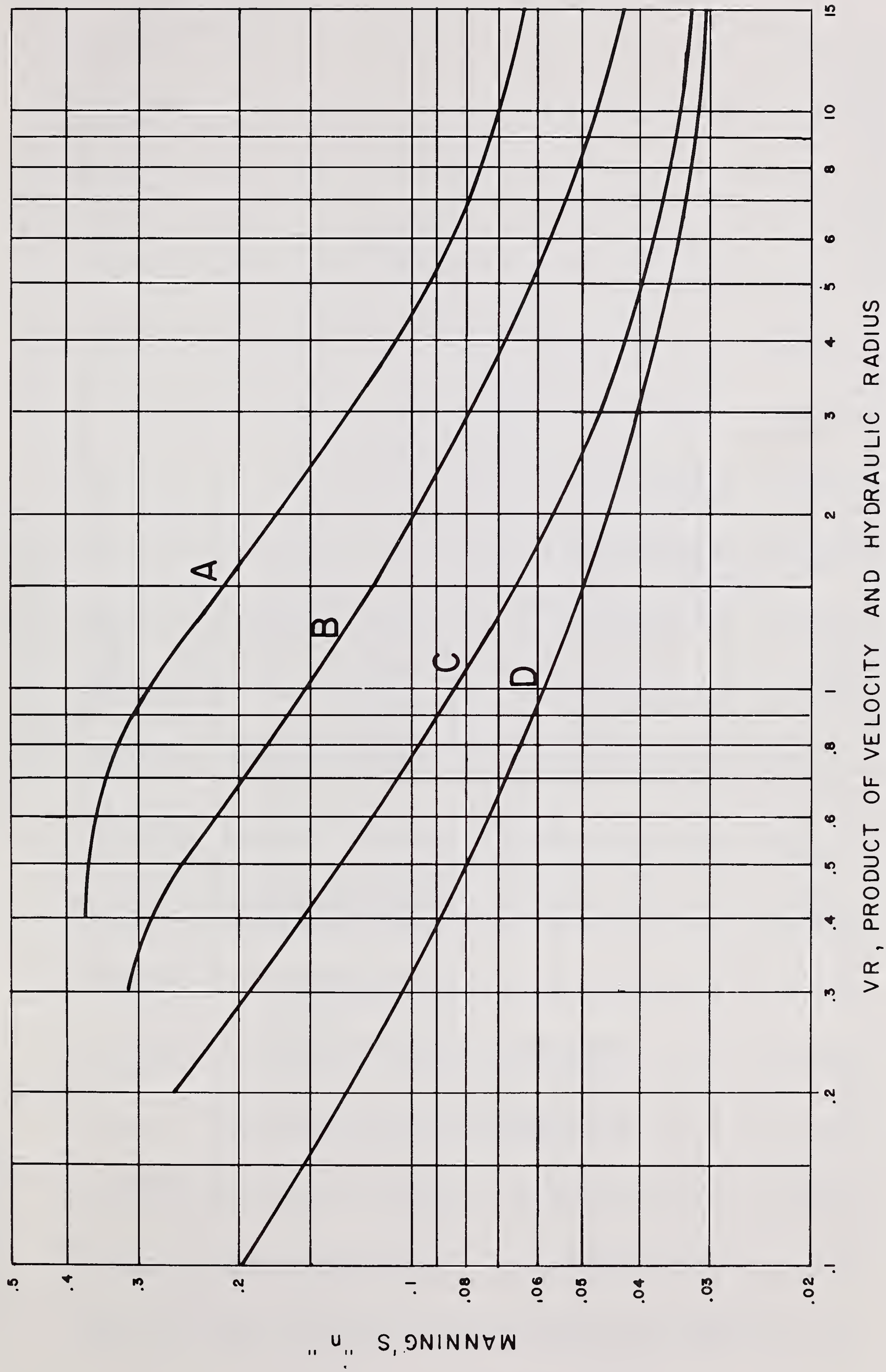
d = 0.9 feet + freeboard.

GRASSED WATERWAY AND DIVERSION

DESIGN TABLE (15)

Retardance	Cover	Stand	Condition and Height
A	Reed canarygrass	Excellent	Tall (Average 36")
	Kentucky 31 tall fescue	Excellent	Tall (Average 36")
B	Tufcote, Midland and Coastal bermudagrass	Good	Tall (Average 12")
	Reed canarygrass	Good	Mowed (Avg. 12 to 15")
	Kentucky 31 tall fescue	Good	Unmowed (Avg. 18")
	Red fescue	Good	Unmowed (Avg. 16")
	Kentucky bluegrass	Good	Unmowed (Avg. 16")
	Redtop	Good	Average 22"
C	Kentucky bluegrass	Good	Headed (6 to 12")
	Red fescue	Good	Headed (6 to 12")
	Tufcote, Midland and Coastal bermudagrass	Good	Mowed (Average 6")
	Redtop	Good	Headed (15 to 20")
D	Tufcote, Midland and Coastal bermudagrass	Good	Mowed (2 1/2")
	Red fescue	Good	Mowed (2 1/2")
	Kentucky bluegrass	Good	Mowed (2 - 5")

Classification of vegetal cover in waterways and diversions based on degree of flow retardance.



Manning's "n" related to velocity, hydraulic radius, and vegetal retardance. (15)

V for Retardance "D",
T and D for Retardance "C"

Parabolic Waterway Design

Grade 0.25 Percent(14)

Q cfs	V = 2.0		V = 2.5		V = 3.0		V = 3.5		V = 4.0		V = 4.5		V = 5.0		V = 5.5		V = 6.0	
	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D
15																		
20																		
25	10	2.4																
30	11	2.3																
35	13	2.3																
40	15	2.3	10	2.7														
45	17	2.2	12	2.6														
50	19	2.2	13	2.6														
55	20	2.2	14	2.6														
60	22	2.2	15	2.5														
65	24	2.2	17	2.5														
70	26	2.2	18	2.5	13	3.1												
75	28	2.2	19	2.5	13	3.0												
80	29	2.2	20	2.5	14	3.0												
90	33	2.2	23	2.5	16	3.0												
100	38	2.2	25	2.5	18	3.0												
110	40	2.2	28	2.5	19	2.9												
120	44	2.2	30	2.5	21	2.9	15	3.6										
130	48	2.2	33	2.5	23	2.9	16	3.6										
140	51	2.2	35	2.5	25	2.9	18	3.5										
150	55	2.2	37	2.5	26	2.9	19	3.5										
160	58	2.2	40	2.5	28	2.9	20	3.5										
170	62	2.2	42	2.5	30	2.9	21	3.5	17	4.0								
180	66	2.2	45	2.5	31	2.9	22	3.5	18	4.0								

Q = Flow in Cubic Feet per Second, V = Velocity in Feet per Second, T = Top Width in Feet
D = Depth in Feet

V for Retardance "D",
T and D for Retardance "C"

Parabolic Waterway Design

Grade 0.50 Percent

Q cfs	V = 2.0		V = 2.5		V = 3.0		V = 3.5		V = 4.0		V = 4.5		V = 5.0		V = 5.5		V = 6.0	
	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D
15	9	1.6																
20	11	1.6																
25	14	1.6	9	1.9														
30	17	1.6	11	1.9	8	2.2												
35	20	1.6	12	1.9	9	2.1												
40	22	1.6	14	1.8	11	2.1												
45	25	1.5	16	1.8	12	2.0												
50	28	1.5	18	1.8	13	2.0	10	2.4										
55	31	1.5	19	1.8	15	2.0	11	2.4										
60	33	1.5	21	1.8	16	2.0	11	2.4										
65	36	1.5	23	1.8	17	2.0	12	2.4										
70	39	1.5	24	1.8	18	2.0	13	2.3										
75	42	1.5	26	1.8	20	2.0	14	2.3	11	2.7								
80	44	1.5	28	1.8	21	2.0	15	2.3	12	2.7								
90	50	1.5	31	1.8	24	2.0	17	2.3	13	2.7								
100	55	1.5	35	1.8	26	2.0	19	2.3	15	2.6	12	3.0						
110	61	1.5	38	1.8	29	2.0	21	2.3	16	2.6	13	3.0						
120	66	1.5	42	1.8	31	2.0	22	2.3	18	2.6	14	2.9						
130	72	1.5	45	1.8	34	2.0	24	2.3	19	2.6	15	2.9						
140	77	1.5	48	1.8	36	2.0	26	2.3	20	2.6	16	2.9						
150	83	1.5	52	1.8	39	2.0	28	2.3	22	2.6	18	2.9	14	3.3				
160	88	1.5	55	1.8	41	2.0	30	2.3	23	2.6	19	2.9	15	3.3				
170	93	1.5	59	1.8	44	2.0	32	2.3	25	2.6	20	2.9	16	3.3				
180	99	1.5	62	1.8	47	2.0	33	2.3	26	2.6	21	2.9	17	3.3				

Q = Flow in Cubic Feet per Second, V = Velocity in Feet per Second, T = Top Width in Feet
D = Depth in Feet

V for Retardance "D",
T and D for Retardance "C"

Parabolic Waterway Design

Grade 0.75 Percent

Q	V = 2.0		V = 2.5		V = 3.0		V = 3.5		V = 4.0		V = 4.5		V = 5.0		V = 5.5		V = 6.0	
cfs	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D
15	12	1.3	7	1.6														
20	16	1.3	9	1.5														
25	19	1.3	11	1.5	8	1.7												
30	23	1.3	13	1.5	10	1.7	8	1.9										
35	27	1.3	15	1.5	11	1.7	9	1.9										
40	31	1.3	18	1.5	13	1.7	10	1.9										
45	35	1.3	20	1.5	14	1.7	11	1.8										
50	38	1.3	22	1.5	16	1.6	13	1.8	9	2.2								
55	42	1.3	24	1.5	18	1.6	14	1.8	10	2.1								
60	46	1.3	26	1.5	19	1.6	15	1.8	11	2.1								
65	50	1.3	28	1.5	21	1.6	16	1.8	12	2.1	10	2.4						
70	53	1.3	30	1.5	22	1.6	17	1.8	13	2.1	11	2.4						
75	57	1.3	33	1.5	24	1.6	19	1.8	14	2.1	11.	2.3						
80	61	1.3	35	1.5	25	1.6	20	1.8	15	2.1	12	2.3						
90	68	1.3	39	1.5	28	1.6	22	1.8	16	2.1	13	2.3	11	2.6				
100	76	1.3	43	1.5	32	1.6	25	1.8	18	2.1	15	2.3	12	2.6				
110	83	1.3	48	1.5	35	1.6	27	1.8	20	2.0	16	2.3	13	2.6				
120	91	1.3	52	1.5	38	1.6	30	1.8	22	2.1	18	2.3	15	2.5	12	2.9		
130	98	1.3	56	1.5	41	1.6	32	1.8	23	2.1	19	2.2	16	2.5	13	2.8		
140	106	1.3	60	1.5	44	1.6	34	1.8	25	2.0	21	2.3	17	2.5	14	2.8		
150	113	1.3	65	1.5	47	1.6	37	1.8	27	2.0	22	2.2	18	2.5	15	2.8		
160	121	1.3	69	1.5	50	1.6	39	1.8	29	2.0	24	2.2	19	2.5	16	2.8	13	3.1
170	128	1.3	73	1.5	53	1.6	42	1.8	30	2.0	25	2.2	20	2.5	17	2.8	14	3.1
180	135	1.3	77	1.5	56	1.6	44	1.8	32	2.0	27	2.2	22	2.5	18	2.8	15	3.1

Q = Flow in Cubic Feet per Second, V = Velocity in Feet per Second, T = Top Width in Feet
D = Depth in Feet

V for Retardance "D",
T and D for Retardance "C"

Parabolic Waterway Design

Grade 1.0 Percent

Q cfs	V = 2.0 T	V = 2.0 D	V = 2.5 T	V = 2.5 D	V = 3.0 T	V = 3.0 D	V = 3.5 T	V = 3.5 D	V = 4.0 T	V = 4.0 D	V = 4.5 T	V = 4.5 D	V = 5.0 T	V = 5.0 D	V = 5.5 T	V = 5.5 D	V = 6.0 T	V = 6.0 D
15	13	1.1	8	1.3														
20	18	1.1	11	1.3	8	1.5												
25	22	1.1	14	1.3	9	1.5	8	1.6										
30	27	1.1	17	1.3	11	1.5	9	1.6										
35	31	1.1	19	1.3	13	1.5	11	1.6	8	1.8								
40	35	1.1	22	1.3	15	1.4	12	1.6	9	1.8								
45	40	1.1	25	1.3	17	1.5	13	1.6	10	1.8								
50	44	1.1	28	1.3	19	1.4	15	1.6	11	1.8	9	2.0						
55	48	1.1	30	1.3	20	1.4	16	1.5	12	1.8	10	2.0						
60	53	1.1	33	1.3	22	1.4	18	1.5	14	1.7	10	2.0						
65	57	1.1	36	1.3	24	1.4	19	1.5	15	1.7	11	2.0	9	2.2				
70	61	1.1	38	1.3	26	1.4	21	1.5	16	1.7	12	2.0	10	2.2				
75	66	1.1	41	1.3	28	1.4	22	1.5	17	1.7	13	2.0	11	2.2				
80	70	1.1	44	1.3	29	1.4	24	1.5	18	1.7	14	2.0	11	2.2				
90	79	1.1	49	1.3	33	1.4	27	1.5	20	1.7	15	1.9	13	2.2	11	2.4		
100	87	1.1	55	1.3	37	1.4	29	1.5	22	1.7	17	1.9	14	2.2	12	2.4		
110	96	1.1	60	1.3	40	1.4	32	1.5	24	1.7	19	1.9	15	2.1	13	2.4	11	2.6
120	104	1.1	65	1.3	44	1.4	35	1.5	27	1.7	20	1.9	17	2.1	14	2.4	12	2.6
130	113	1.1	71	1.3	47	1.4	38	1.5	29	1.7	22	1.9	18	2.1	15	2.4	13	2.6
140	121	1.1	76	1.3	51	1.4	41	1.5	31	1.7	24	1.9	20	2.1	16	2.3	14	2.6
150	130	1.1	81	1.3	55	1.4	44	1.5	33	1.7	25	1.9	21	2.1	17	2.4	15	2.6
160	138	1.1	87	1.3	58	1.4	47	1.5	35	1.7	27	1.9	22	2.1	19	2.3	16	2.5
170	147	1.1	92	1.3	62	1.4	50	1.5	38	1.7	29	1.9	24	2.1	20	2.3	17	2.5
180	155	1.1	97	1.3	65	1.4	53	1.5	40	1.7	30	1.9	25	2.1	21	2.3	18	2.5

Q = Flow in Cubic Feet per Second, V = Velocity in Feet per Second, T = Top Width in Feet
D = Depth in Feet

V for Retardance "D",
T and D for Retardance "C"

Parabolic Waterway Design

Grade 1.25 Percent

Q cfs	V = 2.0 T	V = 2.0 D	V = 2.5 T	V = 2.5 D	V = 3.0 T	V = 3.0 D	V = 3.5 T	V = 3.5 D	V = 4.0 T	V = 4.0 D	V = 4.5 T	V = 4.5 D	V = 5.0 T	V = 5.0 D	V = 5.5 T	V = 5.5 D	V = 6.0 T	V = 6.0 D
15	15	1.0	10	1.2	7	1.4												
20	20	1.0	13	1.1	9	1.3	7	1.5										
25	25	1.0	16	1.1	11	1.3	8	1.5	7	1.6								
30	31	1.0	19	1.1	13	1.3	10	1.4	8	1.6								
35	36	1.0	23	1.1	15	1.3	11	1.4	9	1.6	7	1.8						
40	41	1.0	26	1.1	17	1.3	13	1.4	11	1.6	8	1.8						
45	46	1.0	29	1.1	19	1.3	14	1.4	12	1.5	9	1.7						
50	50	1.0	32	1.1	21	1.3	16	1.4	13	1.5	10	1.7	8	2.0				
55	55	1.0	35	1.1	23	1.3	18	1.4	14	1.5	11	1.7	9	1.9				
60	60	1.0	38	1.1	26	1.3	19	1.4	16	1.5	12	1.7	10	1.9				
65	65	1.0	41	1.1	28	1.3	21	1.4	17	1.5	13	1.7	11	1.9	9	2.2		
70	70	1.0	45	1.1	30	1.3	22	1.4	18	1.5	14	1.7	11	1.9	9	2.2		
75	75	1.0	48	1.1	32	1.3	24	1.4	19	1.5	15	1.7	12	1.9	10	2.1		
80	80	1.0	51	1.1	34	1.3	25	1.4	21	1.5	16	1.7	13	1.9	11	2.1	9	2.3
90	90	1.0	57	1.1	38	1.3	29	1.4	23	1.5	18	1.7	15	1.9	12	2.1	10	2.3
100	100	1.0	63	1.1	42	1.3	32	1.4	26	1.5	20	1.7	16	1.9	13	2.1	11	2.3
110	109	1.0	70	1.1	46	1.3	35	1.4	28	1.5	22	1.7	18	1.9	14	2.1	12	2.2
120	119	1.0	76	1.1	51	1.3	38	1.4	31	1.5	24	1.7	19	1.8	16	2.1	14	2.2
130	129	1.0	82	1.1	55	1.3	41	1.4	33	1.5	26	1.7	21	1.8	17	2.1	15	2.2
140	139	1.0	88	1.1	59	1.3	44	1.4	36	1.5	28	1.7	23	1.8	18	2.1	16	2.2
150	148	1.0	94	1.1	63	1.3	47	1.4	38	1.5	30	1.7	24	1.8	19	2.0	17	2.2
160	158	1.0	101	1.1	67	1.3	50	1.4	41	1.5	32	1.7	26	1.8	21	2.1	18	2.2
170	168	1.0	107	1.1	71	1.3	54	1.4	43	1.5	34	1.7	27	1.8	22	2.1	19	2.2
180	177	1.0	113	1.1	75	1.3	57	1.4	46	1.5	36	1.7	29	1.8	23	2.1	20	2.2

Q = Flow in Cubic Feet per Second, V = Velocity in Feet per Second, T = Top Width in Feet
D = Depth in Feet

V for Retardance "D",
T and D for Retardance "C"

Parabolic Waterway Design

Grade 1.50 Percent

Q cfs	V = 2.0 T	V = 2.0 D	V = 2.5 T	V = 2.5 D	V = 3.0 T	V = 3.0 D	V = 3.5 T	V = 3.5 D	V = 4.0 T	V = 4.0 D	V = 4.5 T	V = 4.5 D	V = 5.0 T	V = 5.0 D	V = 5.5 T	V = 5.5 D	V = 6.0 T	V = 6.0 D
15	17	0.9	11	1.1	8	1.2												
20	23	0.9	15	1.0	10	1.2	7	1.4	6	1.5								
25	28	0.9	19	1.0	12	1.2	9	1.4	7	1.5								
30	34	0.9	22	1.0	15	1.2	10	1.3	8	1.5	7	1.6						
35	40	0.9	26	1.0	17	1.1	12	1.3	10	1.4	8	1.6						
40	45	0.9	30	1.0	20	1.2	14	1.3	11	1.4	9	1.6	7	1.8				
45	51	0.9	33	1.0	22	1.1	15	1.3	12	1.4	10	1.5	8	1.8				
50	56	0.9	37	1.0	25	1.1	17	1.3	14	1.4	11	1.5	9	1.8				
55	62	0.9	41	1.0	27	1.1	19	1.3	15	1.4	12	1.5	10	1.7	8	1.9		
60	67	0.9	44	1.0	30	1.1	20	1.3	16	1.4	14	1.5	11	1.7	9	1.9		
65	73	0.9	48	1.0	32	1.1	22	1.3	18	1.4	15	1.5	11	1.7	10	1.9		
70	78	0.9	51	1.0	34	1.1	24	1.3	19	1.4	16	1.5	12	1.7	10	1.9	9	2.1
75	83	0.9	55	1.0	37	1.1	25	1.3	21	1.4	17	1.5	13	1.7	11	1.9	9	2.1
80	89	0.9	59	1.0	39	1.1	27	1.3	22	1.4	18	1.5	14	1.7	12	1.9	10	2.1
90	100	0.9	66	1.0	44	1.1	30	1.3	25	1.4	20	1.5	16	1.7	13	1.9	11	2.0
100	111	0.9	73	1.0	49	1.1	33	1.3	27	1.4	22	1.5	17	1.7	15	1.9	12	2.0
110	121	0.9	80	1.0	54	1.1	37	1.3	30	1.4	25	1.5	19	1.7	16	1.8	14	2.0
120	132	0.9	87	1.0	58	1.1	40	1.3	33	1.4	27	1.5	21	1.7	18	1.9	15	2.0
130	143	0.9	95	1.0	63	1.1	43	1.3	35	1.4	29	1.5	22	1.7	19	1.8	16	2.0
140	154	0.9	102	1.0	68	1.1	47	1.3	38	1.4	31	1.5	24	1.7	20	1.8	17	2.0
150	164	0.9	109	1.0	73	1.1	50	1.3	41	1.4	33	1.5	26	1.7	22	1.8	18	2.0
160	175	0.9	116	1.0	78	1.1	53	1.3	43	1.4	36	1.5	27	1.7	23	1.8	20	2.0
170	186	0.9	123	1.0	82	1.1	57	1.3	46	1.4	38	1.5	29	1.7	25	1.8	21	2.0
180	196	0.9	130	1.0	87	1.1	60	1.3	49	1.4	40	1.5	31	1.7	26	1.8	22	2.0

Q = Flow in Cubic Feet per Second, V = Velocity in Feet per Second, T = Top Width in Feet
D = Depth in Feet

V for Retardance "D",
T and D for Retardance "C"

Parabolic Waterway Design

Grade 1.75 Percent

Q cfs	V = 2.0		V = 2.5		V = 3.0		V = 4.5		V = 4.0		V = 4.5		V = 5.0		V = 5.5		V = 6.0	
	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D
15	19	0.9	12	1.0	9	1.1	6	1.3										
20	25	0.9	16	1.0	11	1.1	8	1.3	7	1.3								
25	31	0.9	20	1.0	14	1.1	10	1.2	8	1.3	7	1.5						
30	37	0.9	24	1.0	17	1.1	12	1.2	10	1.3	8	1.4						
35	43	0.9	28	1.0	20	1.1	13	1.2	11	1.3	9	1.4	7	1.6				
40	49	0.9	32	1.0	22	1.1	15	1.2	13	1.3	10	1.4	8	1.6				
45	55	0.9	36	1.0	25	1.1	17	1.2	14	1.3	12	1.4	9	1.6	8	1.7		
50	61	0.9	40	1.0	28	1.1	19	1.2	16	1.3	13	1.4	10	1.5	8	1.7		
55	67	0.9	44	1.0	31	1.1	21	1.2	17	1.3	14	1.4	11	1.5	9	1.7	8	1.9
60	73	0.9	48	1.0	33	1.1	23	1.2	19	1.3	15	1.4	12	1.5	10	1.7	8	1.9
65	78	0.9	52	1.0	36	1.1	25	1.2	21	1.3	17	1.4	13	1.5	11	1.7	9	1.9
70	84	0.9	56	1.0	39	1.1	27	1.2	22	1.3	18	1.4	14	1.5	12	1.7	10	1.9
75	90	0.9	59	1.0	42	1.1	29	1.2	24	1.3	19	1.4	15	1.5	12	1.7	10	1.9
80	96	0.9	63	1.0	44	1.1	30	1.2	25	1.3	20	1.4	16	1.5	13	1.7	11	1.9
90	108	0.9	71	1.0	50	1.1	34	1.2	28	1.3	23	1.4	18	1.5	15	1.7	12	1.9
100	120	0.9	79	1.0	55	1.1	38	1.2	31	1.3	25	1.4	20	1.5	16	1.7	13	1.9
110	131	0.9	87	1.0	61	1.1	42	1.2	34	1.3	28	1.4	22	1.5	18	1.7	15	1.8
120	143	0.9	94	1.0	66	1.1	45	1.2	38	1.3	30	1.4	24	1.5	20	1.7	16	1.8
130	155	0.9	102	1.0	71	1.1	49	1.2	41	1.3	33	1.4	26	1.5	21	1.7	17	1.8
140	166	0.9	110	1.0	77	1.1	53	1.2	44	1.3	35	1.4	28	1.5	23	1.6	19	1.8
150	178	0.9	117	1.0	82	1.1	56	1.2	47	1.3	38	1.4	30	1.5	24	1.6	20	1.8
160	189	0.9	125	1.0	88	1.1	60	1.2	50	1.3	40	1.4	31	1.5	26	1.6	21	1.8
170	201	0.9	132	1.0	93	1.1	64	1.2	53	1.3	43	1.4	33	1.5	28	1.6	23	1.8
180	212	0.9	140	1.0	98	1.1	67	1.2	56	1.3	45	1.4	35	1.5	29	1.6	24	1.8

Q = Flow in Cubic Feet per Second, V = Velocity in Feet per Second, T = Top Width in Feet
D = Depth in Feet

V for Retardance "D",
T and D for Retardance "C"

Parabolic Waterway Design

Grade 2.0 Percent

Q cfs	V = 2.0		V = 2.5		V = 3.0		V = 3.5		V = 4.0		V = 4.5		V = 5.0		V = 5.5		V = 6.0	
	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D
15	21	0.8	13	0.9	9	1.0	7	1.2										
20	28	0.8	17	0.9	12	1.0	9	1.1	7	1.3	5	1.4						
25	35	0.8	21	0.9	15	1.0	11	1.1	8	1.3	7	1.4						
30	41	0.8	26	0.9	18	1.0	13	1.1	10	1.2	8	1.3	7	1.5				
35	48	0.8	30	0.9	22	1.0	15	1.1	11	1.2	9	1.3	8	1.5				
40	55	0.8	34	0.9	25	1.0	18	1.1	13	1.2	11	1.3	9	1.5	7	1.7		
45	62	0.8	38	0.9	28	1.0	20	1.1	14	1.2	12	1.3	10	1.4	8	1.6		
50	68	0.8	42	0.9	31	1.0	22	1.1	16	1.2	13	1.3	11	1.4	9	1.6	8	1.7
55	75	0.8	46	0.9	34	1.0	24	1.1	17	1.2	14	1.3	12	1.4	10	1.6	8	1.7
60	82	0.8	51	0.9	37	1.0	26	1.1	19	1.2	16	1.3	13	1.4	11	1.6	9	1.7
65	88	0.8	55	0.9	40	1.0	28	1.1	21	1.2	17	1.3	14	1.4	11	1.6	10	1.7
70	95	0.8	59	0.9	43	1.0	30	1.1	22	1.2	18	1.3	15	1.4	12	1.6	10	1.7
75	101	0.8	63	0.9	46	1.0	32	1.1	24	1.2	20	1.3	16	1.4	13	1.6	11	1.7
80	108	0.8	67	0.9	48	1.0	35	1.1	25	1.2	21	1.3	17	1.4	14	1.6	12	1.7
90	121	0.8	75	0.9	54	1.0	39	1.1	28	1.2	23	1.3	19	1.4	16	1.6	13	1.7
100	134	0.8	83	0.9	60	1.0	43	1.1	31	1.2	26	1.3	21	1.4	17	1.6	15	1.7
110	147	0.8	92	0.9	66	1.0	47	1.1	34	1.2	28	1.3	23	1.4	19	1.5	16	1.7
120	160	0.8	100	0.9	72	1.0	52	1.1	38	1.2	31	1.3	26	1.4	21	1.5	18	1.7
130	173	0.8	108	0.9	78	1.0	56	1.1	41	1.2	34	1.3	28	1.4	23	1.5	19	1.7
140	186	0.8	116	0.9	84	1.0	60	1.1	44	1.2	36	1.3	30	1.4	24	1.5	21	1.7
150	199	0.8	124	0.9	90	1.0	64	1.1	47	1.2	39	1.3	32	1.4	26	1.5	22	1.7
160	212	0.8	132	0.9	96	1.0	69	1.1	50	1.2	41	1.3	34	1.4	28	1.5	23	1.7
170	225	0.8	140	0.9	102	1.0	73	1.1	53	1.2	44	1.3	36	1.4	29	1.5	25	1.7
180	238	0.8	148	0.9	108	1.0	77	1.1	56	1.2	46	1.3	38	1.4	31	1.5	26	1.7

Q = Flow in Cubic Feet per Second, V = Velocity in Feet per Second, T = Top Width in Feet
D = Depth in Feet

V for Retardance "D",
T and D for Retardance "C"

Parabolic Waterway Design

Grade 3.0 Percent

Q cfs	V = 2.0		V = 2.5		V = 3.0		V = 3.5		V = 4.0		V = 4.5		V = 5.0		V = 5.5		V = 6.0	
	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D
15	24	0.7	16	0.8	11	0.8	9	0.9	7	1.0	5	1.2						
20	31	0.7	22	0.8	15	0.8	12	0.9	9	1.0	7	1.1	6	1.2				
25	39	0.7	27	0.8	19	0.8	15	0.9	11	1.0	8	1.1	7	1.2	6	1.3		
30	47	0.7	32	0.8	23	0.8	17	0.9	13	1.0	10	1.1	9	1.2	7	1.2	6	1.4
35	55	0.7	38	0.8	26	0.8	20	0.9	15	1.0	11	1.1	10	1.1	8	1.2	7	1.4
40	62	0.7	43	0.8	30	0.8	23	0.9	17	1.0	13	1.1	12	1.1	9	1.2	8	1.4
45	70	0.7	48	0.8	34	0.8	26	0.9	19	1.0	15	1.1	13	1.1	11	1.2	9	1.3
50	77	0.7	54	0.8	38	0.8	29	0.9	21	1.0	16	1.1	14	1.1	12	1.2	9	1.3
55	85	0.7	59	0.8	41	0.8	32	0.9	23	1.0	18	1.1	16	1.1	13	1.2	10	1.4
60	93	0.7	64	0.8	45	0.8	35	0.9	26	1.0	19	1.1	17	1.1	14	1.2	11	1.3
65	100	0.7	70	0.8	49	0.8	37	0.9	28	1.0	21	1.1	19	1.1	15	1.2	12	1.3
70	107	0.7	74	0.8	52	0.8	40	0.9	30	1.0	22	1.1	20	1.1	16	1.2	13	1.3
75	115	0.7	79	0.8	56	0.8	43	0.9	32	1.0	24	1.1	21	1.1	18	1.2	14	1.3
80	122	0.7	85	0.8	59	0.8	46	0.9	34	1.0	26	1.1	23	1.1	19	1.2	15	1.3
90	137	0.7	95	0.8	67	0.8	51	0.9	38	1.0	29	1.1	26	1.1	21	1.2	17	1.3
100	152	0.7	105	0.8	74	0.8	57	0.9	42	1.0	32	1.1	28	1.1	23	1.2	19	1.3
110	167	0.7	116	0.8	81	0.8	63	0.9	46	1.0	35	1.1	31	1.1	26	1.2	21	1.3
120	181	0.7	126	0.8	89	0.8	68	0.9	51	1.0	38	1.1	34	1.1	28	1.2	22	1.3
130	196	0.7	136	0.8	96	0.8	74	0.9	55	1.0	41	1.1	37	1.1	30	1.2	24	1.3
140	211	0.7	146	0.8	103	0.8	79	0.9	59	1.0	44	1.1	39	1.1	32	1.2	26	1.3
150	225	0.7	156	0.8	110	0.8	85	0.9	63	1.0	47	1.1	42	1.1	35	1.2	28	1.3
160	239	0.7	166	0.8	117	0.8	90	0.9	67	1.0	50	1.1	45	1.1	37	1.2	30	1.3
170	254	0.7	176	0.8	124	0.8	96	0.9	71	1.0	54	1.1	48	1.1	39	1.2	32	1.3
180	268	0.7	186	0.8	131	0.8	101	0.9	75	1.0	57	1.1	50	1.1	41	1.2	33	1.3

Q = Flow in Cubic Feet per Second, V = Velocity in Feet per Second, T = Top Width in Feet
D = Depth in Feet

V for Retardance "D",
T and D for Retardance "C"

Parabolic Waterway Design

Grade 4.0 Percent

Q cfs	V = 2.0 T	D	V = 2.5 T	D	V = 3.0 T	D	V = 3.5 T	D	V = 4.0 T	D	V = 4.5 T	D	V = 5.0 T	D	V = 5.5 T	D	V = 6.0 T	D
15	28	0.6	20	0.7	14	0.7	10	0.8	8	0.9	6	0.9	5	1.1				
20	37	0.6	27	0.7	19	0.7	14	0.8	11	0.8	8	0.9	6	1.0	6	1.1		
25	46	0.6	33	0.7	23	0.7	17	0.8	13	0.8	11	0.9	8	1.0	7	1.1	6	1.2
30	55	0.6	40	0.7	28	0.7	20	0.8	16	0.8	13	0.9	10	1.0	8	1.1	7	1.2
35	64	0.6	46	0.7	32	0.7	24	0.8	18	0.8	15	0.9	11	1.0	10	1.1	8	1.2
40	73	0.6	52	0.7	37	0.7	27	0.8	21	0.8	17	0.9	13	1.0	11	1.0	9	1.1
45	82	0.6	59	0.7	41	0.7	30	0.8	23	0.8	19	0.9	14	1.0	12	1.1	10	1.1
50	91	0.6	65	0.7	46	0.7	34	0.8	26	0.8	21	0.9	16	1.0	14	1.1	11	1.1
55	100	0.6	72	0.7	50	0.7	37	0.8	29	0.8	23	0.9	17	1.0	15	1.0	12	1.1
60	109	0.6	78	0.7	55	0.7	40	0.8	31	0.8	25	0.9	19	1.0	16	1.0	13	1.1
65	117	0.6	84	0.7	59	0.7	44	0.8	34	0.8	27	0.9	20	1.0	18	1.1	14	1.1
70	126	0.6	90	0.7	63	0.7	47	0.8	36	0.8	29	0.9	22	1.0	19	1.0	15	1.1
75	135	0.6	97	0.7	68	0.7	50	0.8	39	0.8	31	0.8	24	1.0	20	1.0	17	1.1
80	143	0.6	103	0.7	72	0.7	53	0.8	41	0.8	33	0.9	25	1.0	21	1.0	18	1.1
90	161	0.6	115	0.7	81	0.7	60	0.8	46	0.8	37	0.9	28	1.0	24	1.0	20	1.1
100	178	0.6	128	0.7	90	0.7	66	0.8	51	0.8	41	0.9	31	1.0	27	1.0	22	1.1
110	195	0.6	140	0.7	99	0.7	73	0.8	56	0.8	45	0.9	34	1.0	29	1.0	24	1.1
120	213	0.6	153	0.7	107	0.7	79	0.8	61	0.8	49	0.9	37	1.0	32	1.0	26	1.1
130	230	0.6	165	0.7	116	0.7	86	0.8	66	0.8	53	0.9	40	1.0	35	1.0	28	1.1
140	247	0.6	177	0.7	125	0.7	92	0.8	71	0.8	57	0.9	43	1.0	37	1.0	31	1.1
150	264	0.6	189	0.7	133	0.7	99	0.8	76	0.8	61	0.9	47	1.0	40	1.0	33	1.1
160	280	0.6	201	0.7	142	0.7	105	0.8	81	0.8	65	0.9	50	1.0	42	1.0	35	1.1
170	297	0.6	213	0.7	150	0.7	112	0.8	86	0.8	69	0.9	53	1.0	45	1.0	37	1.1
180	314	0.6	225	0.7	159	0.7	118	0.8	91	0.8	73	0.9	56	1.0	48	1.0	39	1.1

Q = Flow in Cubic Feet per Second, V = Velocity in Feet per Second, T = Top Width in Feet
D = Depth in Feet

V for Retardance "D",
T and D for Retardance "C"

Parabolic Waterway Design

Sheet 11 of 14

Grade 5.0 Percent

Q cfs	V = 2.0		V = 2.5		V = 3.0		V = 3.5		V = 4.0		V = 4.5		V = 5.0		V = 5.5		V = 6.0	
	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D
15	29	0.6	21	0.6	15	0.7	12	0.7	9	0.8	7	0.8	6	0.9	5	1.0		
20	39	0.6	28	0.6	20	0.7	16	0.7	12	0.8	10	0.8	8	0.9	6	1.0	5	1.1
25	49	0.6	35	0.6	25	0.7	20	0.7	15	0.8	12	0.8	10	0.9	8	1.0	7	1.0
30	58	0.6	42	0.6	30	0.7	24	0.7	18	0.8	14	0.8	11	0.9	9	1.0	8	1.0
35	68	0.6	49	0.6	35	0.7	28	0.7	21	0.8	17	0.8	13	0.9	11	0.9	9	1.0
40	77	0.6	56	0.6	40	0.7	32	0.7	24	0.8	19	0.8	15	0.9	12	0.9	10	1.0
45	86	0.6	63	0.6	44	0.7	36	0.7	27	0.8	21	0.8	17	0.9	14	0.9	12	1.0
50	96	0.6	69	0.6	49	0.7	40	0.7	30	0.8	24	0.8	19	0.9	15	0.9	13	1.0
55	105	0.6	76	0.6	54	0.7	44	0.7	33	0.8	26	0.8	21	0.9	17	0.9	14	1.0
60	114	0.6	83	0.6	59	0.7	48	0.7	36	0.8	28	0.8	22	0.9	18	0.9	15	1.0
65	123	0.6	89	0.6	63	0.7	52	0.7	38	0.8	31	0.8	24	0.9	19	0.9	17	1.0
70	132	0.6	96	0.6	68	0.7	56	0.7	41	0.8	33	0.8	26	0.9	21	0.9	18	1.0
75	142	0.6	102	0.6	73	0.7	59	0.7	44	0.8	35	0.8	28	0.9	22	0.9	19	1.0
80	151	0.6	109	0.6	78	0.7	63	0.7	47	0.8	37	0.8	30	0.9	24	0.9	20	1.0
90	169	0.6	122	0.6	87	0.7	71	0.7	53	0.8	42	0.8	33	0.9	27	0.9	23	1.0
100	187	0.6	136	0.6	97	0.7	79	0.7	59	0.8	47	0.8	37	0.9	30	0.9	26	1.0
110	205	0.6	149	0.6	106	0.7	86	0.7	64	0.8	51	0.8	41	0.9	33	0.9	28	1.0
120	223	0.6	162	0.6	115	0.7	94	0.7	70	0.8	56	0.8	44	0.9	35	0.9	31	1.0
130	241	0.6	175	0.6	125	0.7	102	0.7	76	0.8	60	0.8	48	0.9	38	0.9	33	1.0
140	259	0.6	188	0.6	134	0.7	109	0.7	81	0.8	65	0.8	52	0.9	41	0.9	36	1.0
150	276	0.6	201	0.6	143	0.7	117	0.7	87	0.8	69	0.8	55	0.9	44	0.9	38	1.0
160	294	0.6	213	0.6	152	0.7	124	0.7	93	0.8	74	0.8	59	0.9	47	0.9	40	1.0
170	311	0.6	226	0.6	162	0.7	132	0.7	98	0.8	78	0.8	62	0.9	50	0.9	43	1.0
180	329	0.6	239	0.6	171	0.7	139	0.7	104	0.8	83	0.8	66	0.9	53	0.9	45	1.0

Q = Flow in Cubic Feet per Second, V = Velocity in Feet per Second, T = Top Width in Feet
D = Depth in Feet

V for Retardance "D",
T and D for Retardance "C"

Parabolic Waterway Design

Grade 6.0 Percent

Q cfs	V = 2.0		V = 2.5		V = 3.0		V = 3.5		V = 4.0		V = 4.5		V = 5.0		V = 5.5		V = 6.0	
	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D
15	35	0.5	23	0.6	17	0.6	13	0.7	10	0.7	8	0.8	7	0.8	5	0.9	4	1.0
20	46	0.5	30	0.6	22	0.6	17	0.7	13	0.7	11	0.7	9	0.8	7	0.9	6	1.0
25	57	0.5	37	0.6	28	0.6	21	0.7	17	0.7	13	0.7	11	0.8	9	0.9	7	0.9
30	69	0.5	45	0.6	33	0.6	25	0.7	20	0.7	16	0.7	13	0.8	10	0.9	8	0.9
35	80	0.5	52	0.6	38	0.6	29	0.7	23	0.7	19	0.7	15	0.8	12	0.9	10	0.9
40	91	0.5	59	0.6	44	0.6	33	0.7	26	0.7	21	0.7	17	0.8	14	0.9	11	0.9
45	102	0.5	67	0.6	49	0.6	37	0.7	30	0.7	24	0.7	19	0.8	16	0.9	13	0.9
50	113	0.5	74	0.6	54	0.6	42	0.7	33	0.7	26	0.7	22	0.8	17	0.9	14	0.9
55	123	0.5	81	0.6	60	0.6	46	0.7	36	0.7	29	0.7	24	0.8	19	0.8	15	0.9
60	134	0.5	88	0.6	65	0.6	50	0.7	39	0.7	32	0.7	26	0.8	21	0.8	17	0.9
65	145	0.5	95	0.6	70	0.6	54	0.7	42	0.7	34	0.7	28	0.8	22	0.9	18	0.9
70	155	0.5	102	0.6	75	0.6	58	0.7	45	0.7	37	0.7	30	0.8	24	0.9	19	0.9
75	166	0.5	109	0.6	81	0.6	62	0.7	49	0.7	39	0.7	32	0.8	26	0.8	21	0.9
80	176	0.5	116	0.6	86	0.6	65	0.7	52	0.7	42	0.7	34	0.8	27	0.9	22	0.9
90	198	0.5	130	0.6	96	0.6	73	0.7	58	0.7	47	0.7	38	0.8	31	0.8	25	0.9
100	219	0.5	144	0.6	107	0.6	81	0.7	64	0.7	52	0.7	42	0.8	34	0.9	28	0.9
110	240	0.5	158	0.6	117	0.6	89	0.7	71	0.7	57	0.7	47	0.8	37	0.8	30	0.9
120	261	0.5	172	0.6	127	0.6	97	0.7	77	0.7	62	0.7	51	0.8	41	0.8	33	0.9
130	282	0.5	185	0.6	138	0.6	105	0.7	83	0.7	67	0.7	55	0.8	44	0.8	36	0.9
140	302	0.5	199	0.6	148	0.6	113	0.7	89	0.7	72	0.7	59	0.8	47	0.8	38	0.9
150	323	0.5	213	0.6	158	0.6	121	0.7	96	0.7	77	0.7	63	0.8	50	0.8	41	0.9
160	343	0.5	226	0.6	168	0.6	129	0.7	102	0.7	82	0.7	67	0.8	54	0.9	44	0.9
170	363	0.5	240	0.6	178	0.6	136	0.7	108	0.7	87	0.7	71	0.8	57	0.8	46	0.9
180	383	0.5	253	0.6	188	0.6	144	0.7	114	0.7	92	0.7	75	0.8	60	0.9	49	0.9

Q = Flow in Cubic Feet per Second, V = Velocity in Feet per Second, T = Top Width in Feet
D = Depth in Feet

V for Retardance "D",
T and D for Retardance "C"

Parabolic Waterway Design

Grade 8.0 Percent

Q cfs	V = 2.0		V = 2.5		V = 3.0		V = 3.5		V = 4.0		V = 4.5		V = 5.0		V = 5.5		V = 6.0	
	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D
15	37	0.5	27	0.5	19	0.5	15	0.6	12	0.6	9	0.7	8	0.7	6	0.7	5	0.8
20	49	0.5	35	0.5	25	0.5	20	0.6	16	0.6	13	0.7	10	0.7	9	0.7	7	0.8
25	61	0.5	44	0.5	31	0.5	25	0.6	19	0.6	16	0.7	13	0.7	11	0.7	9	0.8
30	73	0.5	53	0.5	37	0.5	30	0.6	23	0.6	19	0.7	16	0.7	13	0.7	11	0.8
35	85	0.5	61	0.5	43	0.5	35	0.6	27	0.6	22	0.6	18	0.7	15	0.7	12	0.8
40	97	0.5	70	0.5	49	0.5	40	0.6	31	0.6	25	0.6	21	0.7	17	0.7	14	0.8
45	109	0.5	78	0.5	55	0.5	45	0.6	35	0.6	28	0.6	23	0.7	19	0.7	16	0.8
50	120	0.5	87	0.5	61	0.5	50	0.6	38	0.6	31	0.7	26	0.7	21	0.7	17	0.8
55	132	0.5	95	0.5	67	0.5	55	0.6	42	0.6	34	0.7	28	0.7	23	0.7	19	0.8
60	143	0.5	103	0.5	73	0.5	60	0.6	46	0.6	37	0.7	31	0.7	25	0.7	21	0.8
65	155	0.5	111	0.5	79	0.5	65	0.6	50	0.6	40	0.7	33	0.7	27	0.7	23	0.8
70	166	0.5	120	0.5	85	0.5	69	0.6	53	0.6	43	0.6	36	0.7	29	0.7	24	0.8
75	177	0.5	128	0.5	91	0.5	74	0.6	57	0.6	46	0.7	38	0.7	31	0.7	26	0.8
80	188	0.5	136	0.5	96	0.5	79	0.6	61	0.6	49	0.6	41	0.7	33	0.7	28	0.8
90	211	0.5	152	0.5	108	0.6	88	0.6	68	0.6	55	0.7	46	0.7	37	0.7	31	0.8
100	234	0.5	168	0.5	120	0.6	98	0.6	75	0.6	61	0.7	51	0.7	41	0.7	34	0.8
110	256	0.5	185	0.5	131	0.6	108	0.6	83	0.6	67	0.7	57	0.7	46	0.7	38	0.8
120	278	0.5	201	0.5	143	0.6	117	0.6	90	0.6	73	0.7	61	0.7	50	0.7	41	0.8
130	300	0.5	217	0.5	154	0.6	126	0.6	97	0.6	78	0.7	65	0.7	54	0.7	44	0.8
140	322	0.5	233	0.5	166	0.6	136	0.6	104	0.6	84	0.7	70	0.7	58	0.7	48	0.8
150	344	0.5	248	0.5	177	0.6	145	0.6	112	0.6	90	0.7	75	0.7	62	0.7	51	0.8
160	366	0.5	264	0.5	188	0.6	154	0.6	119	0.6	96	0.7	80	0.7	66	0.7	54	0.8
170	387	0.5	280	0.5	199	0.6	164	0.6	126	0.6	102	0.7	85	0.7	70	0.7	58	0.8
180	408	0.5	295	0.5	210	0.6	173	0.6	133	0.6	107	0.7	90	0.7	74	0.7	61	0.8

Q = Flow in Cubic Feet per Second, V = Velocity in Feet per Second, T = Top Width in Feet
D = Depth in Feet

V for Retardance "D",
T and D for Retardance "C"

Parabolic Waterway Design

Grade 10.0 Percent

Q cfs	V = 2.0		V = 2.5		V = 3.0		V = 3.5		V = 4.0		V = 4.5		V = 5.0		V = 5.5		V = 6.0	
	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D
15	45	0.4	33	0.5	23	0.5	17	0.5	13	0.6	11	0.6	9	0.6	7	0.7	6	0.7
20	60	0.4	43	0.5	30	0.5	22	0.5	18	0.6	14	0.6	12	0.6	10	0.7	8	0.7
25	75	0.4	54	0.5	38	0.5	28	0.5	22	0.6	18	0.6	15	0.6	12	0.7	10	0.7
30	89	0.4	64	0.5	45	0.5	33	0.5	27	0.6	21	0.6	18	0.6	15	0.6	12	0.7
35	104	0.4	75	0.5	53	0.5	38	0.5	31	0.6	25	0.6	21	0.6	17	0.7	14	0.7
40	118	0.4	85	0.5	60	0.5	44	0.5	35	0.6	28	0.6	24	0.6	20	0.7	16	0.7
45	132	0.4	95	0.5	67	0.5	49	0.5	40	0.6	32	0.6	27	0.6	22	0.7	18	0.7
50	146	0.4	105	0.5	74	0.5	54	0.5	44	0.6	35	0.6	30	0.6	24	0.7	20	0.7
55	160	0.4	115	0.5	82	0.5	60	0.5	48	0.6	39	0.6	32	0.6	27	0.6	22	0.7
60	174	0.4	125	0.5	87	0.5	65	0.5	52	0.6	42	0.6	35	0.6	29	0.7	24	0.7
65	188	0.4	135	0.5	96	0.5	70	0.5	57	0.6	45	0.6	38	0.6	32	0.7	26	0.7
70	201	0.4	145	0.5	103	0.5	75	0.5	61	0.6	49	0.6	41	0.6	34	0.7	28	0.7
75	215	0.4	155	0.5	110	0.5	80	0.5	65	0.6	52	0.6	44	0.6	36	0.7	30	0.7
80	228	0.4	164	0.5	116	0.5	85	0.5	69	0.6	55	0.6	47	0.6	39	0.7	32	0.7
90	255	0.4	184	0.5	131	0.5	96	0.5	76	0.6	62	0.6	52	0.6	43	0.7	36	0.7
100	282	0.4	204	0.5	145	0.5	106	0.5	86	0.6	69	0.6	58	0.6	48	0.7	40	0.7
110	309	0.4	223	0.5	158	0.5	116	0.5	94	0.6	76	0.6	64	0.6	53	0.7	44	0.7
120	336	0.4	242	0.5	172	0.5	126	0.5	103	0.6	82	0.6	69	0.6	57	0.7	48	0.7
130	362	0.4	262	0.5	186	0.5	137	0.5	111	0.6	89	0.6	75	0.6	62	0.7	52	0.7
140	388	0.4	281	0.5	200	0.5	147	0.5	119	0.6	95	0.6	81	0.6	67	0.7	56	0.7
150	414	0.4	299	0.5	213	0.5	157	0.5	127	0.6	102	0.6	86	0.6	71	0.7	60	0.7
160	440	0.4	318	0.5	227	0.5	166	0.5	135	0.6	108	0.6	92	0.6	76	0.7	64	0.7
170	466	0.4	337	0.5	240	0.5	176	0.5	143	0.6	115	0.6	97	0.6	80	0.7	67	0.7
180	491	0.4	355	0.5	253	0.5	186	0.5	151	0.6	121	0.6	103	0.6	85	0.7	71	0.7

Q = Flow in Cubic Feet per Second, V = Velocity in Feet per Second, T = Top Width in Feet
D = Depth in Feet

Trapezoidal Channel Design

"C" Retardance Grade 0.5 Percent Side Slope = 2:1

Bottom Width, b, in Feet

Q cfs	b = 2 D	b = 2 V	b = 4 D	b = 4 V	b = 6 D	b = 6 V	b = 8 D	b = 8 V	b = 10 D	b = 10 V	b = 12 D	b = 12 V	b = 14 D	b = 14 V	b = 16 D	b = 16 V
15	2.1	1.1	1.8	1.1	1.6	1.0	1.5	1.0	1.3	0.9	1.3	0.8	1.2	0.8	1.2	0.7
20	2.3	1.3	1.9	1.3	1.7	1.2	1.5	1.2	1.4	1.1	1.4	1.0	1.3	0.9	1.2	0.9
25	2.4	1.5	2.1	1.5	1.8	1.4	1.7	1.3	1.5	1.2	1.4	1.2	1.4	1.1	1.3	1.0
30	2.5	1.7	2.2	1.6	1.9	1.6	1.7	1.5	1.6	1.4	1.5	1.3	1.4	1.2	1.4	1.2
35	2.7	1.8	2.3	1.8	2.0	1.7	1.8	1.6	1.7	1.5	1.6	1.5	1.5	1.4	1.4	1.3
40	2.8	1.9	2.4	1.9	2.1	1.8	1.9	1.8	1.8	1.7	1.7	1.6	1.6	1.5	1.5	1.4
45	2.9	2.0	2.5	2.0	2.2	1.9	2.0	1.9	1.8	1.8	1.7	1.7	1.6	1.6	1.6	1.5
50	2.9	2.1	2.6	2.1	2.3	2.1	2.1	2.0	1.9	1.9	1.8	1.8	1.7	1.7	1.6	1.6
55	3.0	2.2	2.7	2.2	2.4	2.2	2.2	2.1	2.0	2.0	1.9	1.9	1.8	1.8	1.7	1.7
60	3.1	2.3	2.8	2.3	2.5	2.2	2.2	2.2	2.0	2.1	1.9	2.0	1.8	1.9	1.7	1.8
65	3.2	2.4	2.8	2.4	2.5	2.3	2.3	2.2	2.1	2.2	2.0	2.1	1.9	2.0	1.8	1.9
70	3.3	2.5	2.9	2.4	2.6	2.4	2.4	2.3	2.2	2.2	2.0	2.2	1.9	2.1	1.8	2.0
75	3.4	2.5	3.0	2.5	2.7	2.5	2.4	2.4	2.2	2.3	2.1	2.2	1.9	2.1	1.8	2.1
80	3.4	2.6	3.1	2.6	2.7	2.5	2.5	2.5	2.3	2.4	2.1	2.3	2.0	2.2	1.9	2.1
90	3.6	2.7	3.2	2.7	2.9	2.7	2.6	2.6	2.4	2.5	2.2	2.4	2.1	2.3	2.0	2.3
100	3.7	2.8	3.3	2.8	3.0	2.8	2.7	2.7	2.5	2.7	2.3	2.6	2.2	2.5	2.1	2.4
110	3.9	2.9	3.5	2.9	3.1	2.9	2.8	2.8	2.6	2.8	2.4	2.7	2.3	2.6	2.2	2.5
120	4.0	3.1	3.5	3.0	3.2	3.0	2.9	3.0	2.7	2.9	2.5	2.8	2.4	2.7	2.2	2.6
130	4.1	3.1	3.7	3.1	3.3	3.1	3.0	3.0	2.8	3.0	2.6	2.9	2.5	2.8	2.3	2.7
140	4.2	3.2	3.8	3.2	3.4	3.2	3.1	3.1	2.9	3.1	2.7	3.0	2.5	2.9	2.4	2.8
150	4.3	3.3	3.9	3.3	3.5	3.3	3.2	3.2	3.0	3.1	2.8	3.1	2.6	3.0	2.5	2.9
160	4.4	3.4	4.0	3.4	3.6	3.4	3.3	3.3	3.1	3.2	2.9	3.2	2.7	3.1	2.5	3.0
170	4.5	3.5	4.1	3.5	3.7	3.4	3.4	3.4	3.1	3.3	2.9	3.2	2.8	3.2	2.6	3.1
180	4.6	3.6	4.1	3.6	3.8	3.5	3.5	3.5	3.2	3.4	3.0	3.3	2.8	3.2	2.7	3.2
190	4.6	3.6	4.2	3.6	3.9	3.6	3.6	3.5	3.3	3.5	3.1	3.4	2.9	3.3	2.7	3.2
200	4.7	3.7	4.3	3.7	3.9	3.7	3.6	3.6	3.4	3.5	3.2	3.5	3.0	3.4	2.8	3.3
220	4.9	3.8	4.5	3.8	4.1	3.8	3.8	3.7	3.5	3.7	3.3	3.6	3.1	3.5	2.9	3.4
240	5.0	3.9	4.6	3.9	4.2	3.9	3.9	3.8	3.6	3.8	3.4	3.7	3.2	3.6	3.0	3.6
260	5.2	4.0	4.8	4.0	4.4	4.0	4.1	4.0	3.8	3.9	3.5	3.8	3.3	3.8	3.2	3.7
280	5.3	4.1	4.9	4.1	4.5	4.1	4.2	4.1	3.9	4.0	3.7	4.0	3.6	3.9	3.3	3.8
300	5.5	4.2	5.0	4.2	4.7	4.2	4.3	4.2	4.0	4.1	3.8	4.1	3.6	4.0	3.4	3.9

Q = Flow, Cubic Feet per Second, V = Velocity, Feet per Second, b = Bottom Width, Feet, D = Depth, Feet.

Trapezoidal Channel Design
"C" Retardance Grade 0.5 Percent Side Slope = 2:1

Bottom Width, b, in Feet

Q cfs	b = 2 D	b = 2 V	b = 4 D	b = 4 V	b = 6 D	b = 6 V	b = 8 D	b = 8 V	b = 10 D	b = 10 V	b = 12 D	b = 12 V	b = 14 D	b = 14 V	b = 16 D	b = 16 V
15	1.7	1.6	1.5	1.5	1.3	1.4	1.1	1.3	1.1	1.1	1.0	1.0	1.0	1.0	0.9	0.9
20	1.9	1.8	1.6	1.8	1.4	1.7	1.2	1.5	1.1	1.4	1.1	1.3	1.0	1.2	1.0	1.1
25	2.0	2.1	1.7	2.0	1.5	1.9	1.3	1.8	1.2	1.6	1.2	1.5	1.1	1.4	1.0	1.3
30	2.1	2.3	1.8	2.2	1.6	2.1	1.4	1.9	1.3	1.8	1.2	1.7	1.2	1.6	1.1	1.5
35	2.2	2.5	1.9	2.4	1.6	2.3	1.5	2.1	1.4	2.0	1.3	1.9	1.2	1.8	1.2	1.7
40	2.3	2.6	2.0	2.5	1.7	2.5	1.6	2.3	1.4	2.2	1.3	2.0	1.3	1.9	1.2	1.8
45	2.4	2.8	2.0	2.7	1.8	2.6	1.6	2.5	1.5	2.3	1.4	2.2	1.3	2.1	1.2	2.0
50	2.5	2.9	2.1	2.8	1.9	2.7	1.7	2.6	1.5	2.5	1.4	2.3	1.4	2.2	1.3	2.1
55	2.6	3.0	2.2	2.9	1.9	2.9	1.8	2.7	1.6	2.6	1.5	2.5	1.4	2.3	1.3	2.2
60	2.6	3.1	2.3	3.1	2.0	2.9	1.8	2.9	1.7	2.7	1.5	2.6	1.5	2.4	1.4	2.3
65	2.7	3.2	2.4	3.1	2.1	3.1	1.9	2.9	1.7	2.8	1.6	2.7	1.5	2.6	1.4	2.4
70	2.8	3.3	2.4	3.3	2.1	3.2	2.0	3.1	1.8	2.9	1.6	2.8	1.5	2.7	1.5	2.6
75	2.8	3.4	2.5	3.4	2.2	3.3	2.0	3.1	1.8	3.0	1.7	2.9	1.6	2.8	1.5	2.7
80	2.9	3.5	2.5	3.4	2.3	3.4	2.0	3.3	1.9	3.1	1.7	3.0	1.7	2.9	1.5	2.7
90	3.0	3.6	2.7	3.6	2.4	3.5	2.1	3.4	2.0	3.3	1.8	3.2	1.7	3.0	1.6	2.9
100	3.1	3.8	2.8	3.8	2.5	3.7	2.2	3.6	2.1	3.5	1.9	3.3	1.8	3.2	1.7	3.1
110	3.3	4.0	2.9	3.9	2.6	3.8	2.3	3.7	2.1	3.6	2.0	3.5	1.9	3.3	1.8	3.2
120	3.4	4.1	3.0	4.0	2.7	4.0	2.4	3.9	2.2	3.7	2.1	3.6	1.9	3.5	1.8	3.4
130	3.5	4.2	3.1	4.1	2.8	4.1	2.5	4.0	2.3	3.9	2.1	3.7	2.0	3.6	1.9	3.5
140	3.6	4.3	3.2	4.3	2.8	4.2	2.6	4.1	2.4	4.0	2.2	3.9	2.1	3.8	1.9	3.6
150	3.7	4.4	3.3	4.4	2.9	4.3	2.7	4.2	2.4	4.1	2.3	4.0	2.1	3.9	2.0	3.7
160	3.7	4.5	3.3	4.5	3.0	4.4	2.7	4.4	2.5	4.2	2.3	4.1	2.2	4.0	2.1	3.9
170	3.8	4.6	3.4	4.6	3.1	4.5	2.8	4.4	2.6	4.3	2.4	4.2	2.2	4.1	2.1	4.0
180	3.9	4.7	3.5	4.7	3.1	4.6	2.9	4.5	2.7	4.4	2.5	4.3	2.3	4.2	2.2	4.1
190	4.0	4.8	3.6	4.8	3.2	4.7	2.9	4.7	2.7	4.5	2.5	4.4	2.4	4.3	2.2	4.2
200	4.1	4.9	3.6	4.9	3.3	4.8	3.0	4.7	2.8	4.6	2.6	4.5	2.4	4.4	2.3	4.2
220	4.2	5.1	3.8	5.0	3.4	5.0	3.1	4.9	2.9	4.8	2.7	4.7	2.5	4.6	2.4	4.4
240	4.3	5.2	3.9	5.2	3.6	5.1	3.3	5.1	3.0	4.9	2.8	4.9	2.6	4.7	2.5	4.6
260	4.4	5.4	4.0	5.3	3.7	5.3	3.4	5.2	3.1	5.1	2.9	5.0	2.7	4.9	2.6	4.8
280	4.6	5.5	4.1	5.5	3.8	5.4	3.5	5.4	3.2	5.2	3.0	5.1	2.8	5.0	2.7	4.9
300	4.7	5.6	4.3	5.6	3.9	5.6	3.6	5.5	3.3	5.4	3.1	5.3	2.9	5.2	2.8	5.1

Q = Flow, Cubic Feet per Second, V = Velocity, Feet per Second, b = Bottom Width, Feet, D = Depth, Feet.

Trapezoidal Channel Design

"C" Retardance   Grade 1.0 Percent   Side Slope 2:1

Bottom Width, b, in Feet

Q cfs	b = 2 D	b = 2 V	b = 4 D	b = 4 V	b = 6 D	b = 6 V	b = 8 D	b = 8 V	b = 10 D	b = 10 V	b = 12 D	b = 12 V	b = 14 D	b = 14 V	b = 16 D	b = 16 V
15	1.4	2.2	1.2	2.0	1.0	1.8	0.9	1.7	0.9	1.5	0.8	1.4	0.8	1.2	0.7	1.1
20	1.5	2.5	1.3	2.4	1.1	2.2	1.0	2.0	0.9	1.8	0.9	1.7	0.8	1.5	0.8	1.4
25	1.7	2.8	1.4	2.7	1.2	2.5	1.1	2.3	1.0	2.1	0.9	2.0	0.9	1.8	0.8	1.7
30	1.8	3.1	1.5	3.0	1.3	2.8	1.1	2.6	1.0	2.4	1.0	2.2	0.9	2.0	0.9	1.9
35	1.9	3.3	1.6	3.2	1.3	3.0	1.2	2.8	1.1	2.6	1.0	2.4	1.0	2.3	0.9	2.1
40	1.9	3.5	1.6	3.4	1.4	3.2	1.3	3.0	1.1	2.8	1.1	2.6	1.0	2.5	1.0	2.3
45	2.0	3.7	1.7	3.6	1.5	3.4	1.3	3.2	1.2	3.0	1.1	2.8	1.1	2.7	1.0	2.5
50	2.1	3.9	1.8	3.7	1.5	3.6	1.4	3.4	1.3	3.2	1.2	3.0	1.1	2.8	1.0	2.7
55	2.2	4.0	1.8	3.9	1.6	3.7	1.4	3.5	1.3	3.3	1.2	3.2	1.1	3.0	1.1	2.8
60	2.2	4.2	1.9	4.1	1.7	3.9	1.5	3.7	1.3	3.5	1.3	3.3	1.2	3.1	1.1	3.0
65	2.3	4.3	1.9	4.2	1.7	4.0	1.5	3.9	1.4	3.6	1.3	3.5	1.2	3.3	1.1	3.1
70	2.4	4.4	2.0	4.3	1.8	4.2	1.6	4.0	1.4	3.8	1.3	3.6	1.2	3.4	1.2	3.3
75	2.4	4.5	2.1	4.5	1.8	4.3	1.6	4.1	1.5	3.9	1.4	3.7	1.3	3.5	1.2	3.4
80	2.5	4.6	2.1	4.5	1.9	4.4	1.7	4.2	1.5	4.0	1.4	3.9	1.3	3.7	1.2	3.5
90	2.6	4.9	2.2	4.8	2.0	4.6	1.7	4.5	1.6	4.3	1.5	4.1	1.4	3.9	1.3	3.7
100	2.7	5.1	2.3	5.0	2.0	4.9	1.8	4.7	1.7	4.5	1.5	4.3	1.4	4.1	1.4	3.9
110	2.8	5.2	2.4	5.2	2.1	5.0	1.9	4.9	1.7	4.7	1.6	4.5	1.5	4.3	1.4	4.1
120	2.9	5.4	2.5	5.4	2.2	5.2	2.0	5.0	1.8	4.9	1.7	4.7	1.6	4.5	1.5	4.3
130	3.0	5.6	2.6	5.5	2.3	5.4	2.1	5.2	1.9	5.0	1.7	4.9	1.6	4.7	1.5	4.5
140	3.0	5.7	2.7	5.6	2.4	5.5	2.1	5.4	1.9	5.2	1.8	5.0	1.7	4.8	1.6	4.7
150	3.1	5.9	2.7	5.8	2.4	5.6	2.2	5.5	2.0	5.4	1.8	5.2	1.7	5.0	1.6	4.8
160	3.2	6.0	2.8	6.0	2.5	5.8	2.2	5.7	2.1	5.5	1.9	5.3	1.8	5.1	1.7	4.9
170					2.6	6.0	2.3	5.8	2.1	5.6	2.0	5.5	1.8	5.2	1.7	5.1
180							2.4	5.9	2.2	5.8	2.0	5.6	1.9	5.4	1.8	5.2
190									2.2	5.9	2.1	5.7	1.9	5.5	1.8	5.4
200									2.3	6.0	2.1	5.8	2.0	5.6	1.9	5.4
220													2.1	5.9	2.0	5.7
240															2.0	5.9

Q = Flow, Cubic Feet per Second, V = Velocity, Feet per Second, b = Bottom Width, Feet, D = Depth, Feet.

Trapezoidal Channel Design

"C" Retardance Grade 2.0 Percent Side Slope = 2:1

Bottom Width, b, in Feet

Q cfs	b = 2 D	b = 2 V	b = 4 D	b = 4 V	b = 6 D	b = 6 V	b = 8 D	b = 8 V	b = 10 D	b = 10 V	b = 12 D	b = 12 V	b = 14 D	b = 14 V	b = 16 D	b = 16 V
15	1.2	3.0	0.9	2.7	0.8	2.4	0.7	2.1	0.7	1.9	0.7	1.7	0.6	1.6	0.6	1.4
20	1.3	3.4	1.0	3.2	0.9	2.9	0.8	2.6	0.7	2.3	0.7	2.1	0.7	1.0	0.6	1.8
25	1.4	3.8	1.1	3.6	1.0	3.3	0.9	3.0	0.8	2.7	0.7	2.5	0.7	2.3	0.7	2.1
30	1.5	4.2	1.2	3.9	1.0	3.6	0.9	3.3	0.8	3.1	0.8	2.8	0.7	2.6	0.7	2.4
35	1.6	4.4	1.3	4.2	1.1	3.9	1.0	3.6	0.9	3.3	0.8	3.1	0.8	2.9	0.7	2.7
40	1.6	4.7	1.3	4.5	1.1	4.2	1.0	3.9	0.9	3.6	0.9	3.4	0.8	3.1	0.8	2.9
45	1.7	4.9	1.4	4.7	1.2	4.5	1.1	4.2	1.0	3.9	0.9	3.6	0.8	3.4	0.8	3.2
50	1.8	5.2	1.5	5.0	1.2	4.7	1.1	4.4	1.0	4.1	0.9	3.9	0.9	3.6	0.8	3.4
55	1.8	5.4	1.5	5.1	1.3	4.9	1.2	4.6	1.0	4.3	1.0	4.0	0.9	3.8	0.9	3.6
60	1.9	5.5	1.6	5.3	1.4	5.1	1.2	4.8	1.1	4.5	1.0	4.2	0.9	4.0	0.9	3.8
65	1.9	5.7	1.6	5.5	1.4	5.3	1.2	5.0	1.1	4.7	1.0	4.4	1.0	4.2	0.9	4.0
70	2.0	5.9	1.7	5.7	1.4	5.5	1.3	5.2	1.2	4.9	1.1	4.6	1.0	4.3	1.0	4.1
75			1.7	5.9	1.5	5.6	1.3	5.3	1.2	5.0	1.1	4.7	1.0	4.5	1.0	4.3
80					1.5	5.8	1.4	5.5	1.2	5.2	1.1	4.9	1.1	4.7	1.0	4.4
90							1.4	5.8	1.3	5.5	1.2	5.2	1.1	5.0	1.1	4.7
100									1.4	5.8	1.3	5.5	1.2	5.2	1.1	5.0
110									1.4	6.0	1.3	5.8	1.2	5.5	1.1	5.2
120											1.4	6.0	1.3	5.7	1.2	5.4
130													1.3	5.9	1.2	5.7
140															1.3	5.9

Q = Flow, Cubic Feet per Second, V = Velocity, Feet per Second, b = Bottom Width, Feet, D = Depth, Feet.

Trapezoidal Channel Design

"C" Retardance   Grade 3 Percent   Side Slope = 2:1

Q cfs	b = 2 D	b = 2 V	b = 4 D	b = 4 V	b = 6 D	b = 6 V	b = 8 D	b = 8 V	b = 10 D	b = 10 V	b = 12 D	b = 12 V	b = 14 D	b = 14 V	b = 16 D	b = 16 V
15	1.0	3.5	0.8	3.2	0.7	2.8	0.6	2.5	0.6	2.2	0.6	2.0	0.5	1.8	0.5	1.7
20	1.1	4.1	0.9	3.7	0.8	3.4	0.7	3.0	0.7	2.7	0.6	2.5	0.6	2.3	0.6	2.1
25	1.2	4.5	1.0	4.2	0.8	3.8	0.8	3.5	0.7	3.2	0.7	2.9	0.6	2.6	0.6	2.5
30	1.3	4.9	1.1	4.6	0.9	4.2	0.8	3.8	0.7	3.5	0.7	3.2	0.7	3.0	0.6	2.8
35	1.4	5.3	1.1	4.9	1.0	4.6	0.9	4.2	0.8	3.9	0.7	3.6	0.7	3.3	0.7	3.1
40	1.5	5.6	1.2	5.3	1.0	4.9	0.9	4.5	0.8	4.2	0.8	3.9	0.7	3.6	0.7	3.3
45	1.5	5.9	1.2	5.6	1.1	5.2	0.9	4.8	0.9	4.5	0.8	4.2	0.8	3.9	0.7	3.6
50			1.3	5.9	1.1	5.4	1.0	5.1	0.9	4.7	0.8	4.4	0.8	4.1	0.7	3.9
55					1.2	5.7	1.0	5.4	0.9	5.0	0.9	4.7	0.8	4.4	0.8	4.1
60					1.2	5.9	1.2	5.6	1.0	5.2	0.9	4.9	0.8	4.6	0.8	4.3
65							1.1	5.8	1.0	5.4	0.9	5.1	0.9	4.8	0.8	4.5
70							1.1	6.0	1.0	5.6	1.0	5.3	0.9	5.0	0.8	4.7
75									1.1	5.8	1.0	5.5	0.9	5.1	0.9	4.9
80											1.0	5.6	0.9	5.3	0.9	5.0
90													1.0	5.6	1.0	5.4
100													1.0	6.0	1.0	5.7
110															1.0	6.0

Bottom Width, b, in Feet

Q = Flow, Cubic Feet per Second, V = Velocity, Feet per Second, b = Bottom Width, Feet, D = Depth, Feet.

Trapezoidal Channel Design

"C" Retardance   Grade 4 Percent   Side Slope = 2:1

Bottom Width, b, in Feet

Q cfs	b = 2		b = 4		b = 6		b = 8		b = 10		b = 12		b = 14		b = 16	
	D	V	D	V	D	V	D	V	D	V	D	V	D	V	D	V
15	1.0	4.0	0.8	3.6	0.7	3.2	0.6	2.8	0.5	2.4	0.5	2.2	0.5	2.0	0.5	1.8
20	1.1	4.6	0.8	4.2	0.7	3.8	0.6	3.3	0.6	3.0	0.6	2.7	0.5	2.5	0.5	2.3
25	1.1	5.1	0.9	4.8	0.8	4.3	0.7	3.8	0.6	3.5	0.6	3.1	0.6	2.9	0.5	2.7
30	1.2	5.6	1.0	5.2	0.8	4.7	0.7	4.3	0.7	3.9	0.6	3.6	0.6	3.3	0.6	3.0
35	1.3	5.9	1.0	5.6	0.9	5.1	0.8	4.7	0.7	4.3	0.7	3.9	0.6	3.6	0.6	3.4
40			1.1	5.9	0.9	5.4	0.8	5.0	0.8	4.6	0.7	4.2	0.6	3.9	0.6	3.7
45					1.0	5.8	0.9	5.4	0.8	4.9	0.7	4.6	0.7	4.3	0.6	4.0
50							0.9	5.6	0.8	5.2	0.8	4.9	0.7	4.6	0.7	4.2
55							0.9	5.9	0.8	5.5	0.8	5.1	0.7	4.8	0.7	4.5
60									0.9	5.8	0.8	5.4	0.8	5.0	0.7	4.8
65									0.9	6.0	0.8	5.6	0.8	5.3	0.7	5.0
70											0.9	5.9	0.9	5.5	0.8	5.2
75													0.9	5.7	0.8	5.4
80													0.9	5.9	0.8	5.6
90															0.9	5.9

Q = Flow, Cubic Feet per Second, V = Velocity, Feet per Second, b = Bottom Width, Feet, D = Depth, Feet.

Trapezoidal Channel Design

"C" Retardance   Grade 5 Percent   Side Slope 2:1

Bottom Width, b, in Feet

Q cfs	b = 2 D	b = 2 V	b = 4 D	b = 4 V	b = 6 D	b = 6 V	b = 8 D	b = 8 V	b = 10 D	b = 10 V	b = 12 D	b = 12 V	b = 14 D	b = 14 V	b = 16 D	b = 16 V
15	0.9	4.4	0.7	3.9	0.6	3.4	0.6	3.0	0.5	2.6	0.5	2.3	0.5	2.1	0.5	2.0
20	1.0	5.1	0.8	4.6	0.7	4.1	0.6	3.6	0.6	3.2	0.5	2.9	0.5	2.7	0.5	2.4
25	1.1	5.6	0.9	5.2	0.7	4.6	0.6	4.2	0.6	3.7	0.6	3.4	0.5	3.1	0.5	2.9
30			0.9	5.6	0.8	5.1	0.7	4.6	0.6	4.2	0.6	3.9	0.6	3.5	0.5	3.3
35					0.8	5.5	0.7	5.1	0.7	4.6	0.6	4.2	0.6	3.9	0.6	3.6
40					0.9	5.9	0.8	5.4	0.7	5.0	0.7	4.6	0.6	4.3	0.6	4.0
45							0.8	5.7	0.7	5.3	0.7	5.0	0.6	4.6	0.6	4.3
50									0.8	5.6	0.7	5.3	0.7	4.9	0.6	4.6
55									0.9	6.0	0.7	5.5	0.7	5.2	0.7	4.9
60											0.8	5.8	0.7	5.4	0.7	5.1
65													0.7	5.7	0.7	5.3
70													0.8	5.9	0.7	5.6
75															0.7	5.8
80															0.8	6.0

Grade 6 Percent

Q cfs	b = 2 D	b = 2 V	b = 4 D	b = 4 V	b = 6 D	b = 6 V	b = 8 D	b = 8 V	b = 10 D	b = 10 V	b = 12 D	b = 12 V	b = 14 D	b = 14 V	b = 16 D	b = 16 V
15	0.9	4.8	0.7	4.2	0.6	3.6	0.5	3.2	0.5	2.8	0.5	2.5	0.4	2.3	0.4	2.1
20	0.9	5.4	0.7	4.9	0.6	4.4	0.6	3.8	0.5	3.4	0.5	3.1	0.5	2.8	0.5	2.6
25			0.8	5.6	0.7	4.9	0.6	4.4	0.6	4.0	0.5	3.6	0.5	3.3	0.5	3.1
30					0.7	5.5	0.7	4.9	0.6	4.5	0.6	4.1	0.5	3.7	0.5	3.5
35					0.8	5.9	0.7	5.4	0.6	4.9	0.6	4.5	0.6	4.2	0.5	3.8
40							0.7	5.8	0.7	5.3	0.6	4.9	0.7	4.5	0.6	4.2
45									0.7	5.6	0.6	5.2	0.6	4.9	0.6	4.6
50											0.7	5.6	0.6	5.2	0.6	4.9
55											0.7	5.8	0.7	5.5	0.6	5.1
60													0.7	5.8	0.6	5.4
65															0.7	5.7
70															0.7	5.9

Q = Flow, Cubic Feet per Second, V = Velocity, Feet per Second, b = Bottom Width, Feet, D = Depth, Feet.

Trapezoidal Channel Design

"C" Retardance Grade 8 Percent Side Slope = 2:1

Bottom Width, b, in Feet

Q cfs	b = 2 D	b = 2 V	b = 4 D	b = 4 V	b = 6 D	b = 6 V	b = 8 D	b = 8 V	b = 10 D	b = 10 V	b = 12 D	b = 12 V	b = 14 D	b = 14 V	b = 16 D	b = 16 V
15	0.8	5.3	0.6	4.7	0.5	4.1	0.5	3.5	0.4	3.1	0.4	2.8	0.4	2.5	0.4	2.3
20			0.7	5.5	0.6	4.8	0.5	4.2	0.5	3.8	0.5	3.4	0.4	3.1	0.4	2.8
25					0.6	5.5	0.6	4.9	0.5	4.4	0.5	4.0	0.5	3.6	0.4	3.3
30							0.6	5.5	0.5	4.9	0.5	4.5	0.5	4.2	0.5	3.8
35							0.6	6.0	0.6	5.5	0.5	5.0	0.5	4.6	0.5	4.2
40									0.6	5.9	0.6	5.4	0.5	5.0	0.5	4.6
45											0.6	5.7	0.6	5.4	0.5	5.0
50													0.6	5.7	0.5	5.3
55															0.6	5.7
60															0.6	6.0

Grade 10 Percent

Q cfs	b = 2 D	b = 2 V	b = 4 D	b = 4 V	b = 6 D	b = 6 V	b = 8 D	b = 8 V	b = 10 D	b = 10 V	b = 12 D	b = 12 V	b = 14 D	b = 14 V	b = 16 D	b = 16 V
15	0.7	5.9	0.6	5.1	0.5	4.4	0.4	3.8	0.4	3.4	0.4	3.0	0.4	2.6	0.4	2.4
20			0.6	6.0	0.5	5.2	0.5	4.6	0.4	4.1	0.4	3.7	0.4	3.4	0.4	3.1
25					0.6	6.0	0.5	5.3	0.5	4.7	0.4	4.3	0.4	3.9	0.4	3.6
30							0.6	5.9	0.5	5.3	0.5	4.9	0.5	4.4	0.4	4.1
35									0.5	5.8	0.5	5.4	0.5	4.9	0.5	4.6
40											0.5	5.8	0.5	5.3	0.5	5.0
45													0.5	5.7	0.5	5.4
50															0.5	5.7

Q = Flow, Cubic Feet per Second, V = Velocity, Feet per Second, b = Bottom Width, Feet, D = Depth, Feet.

STANDARD AND SPECIFICATIONS

FOR

LEVEL SPREADER

Definition

An outlet constructed at zero percent grade across the slope whereby concentrated runoff may be discharged at non-erosive velocities onto undisturbed areas stabilized by existing vegetation.

Purpose

The purpose of the level spreader is to convert a concentrated flow of sediment-free runoff (e.g. diversion outlets) into sheet flow and to outlet it onto areas stabilized by existing vegetation without causing erosion.

Conditions Where Practice Applies

The level spreader is used only in those situations where the spreader can be constructed on undisturbed soil, where the area directly below the level lip is stabilized by existing vegetation, where the drainage area above the spreader is stabilized by existing vegetation, and where the water will not be reconcentrated immediately below the point of discharge.

Design Criteria

The design criteria for level spreader shall be a maximum of 1 cfs per foot of length based on the peak rate of flow from a 10-year frequency rainfall event.

An acceptable simplified method shall be that the length is equal to five feet per acre of drainage area. In any case, the minimum length shall be 5 feet and the maximum length shall be 20 feet.

For situations exceeding this criteria, see Standard and Specifications for Grade Stabilization Structure, Grassed Waterway, etc.

Outlets

Final discharge will be over the level lip protected with fiberglass matting erosion stops and jute or excelsior protective material onto an existing stabilized area. The stabilized area shall have a complete vegetative cover sufficiently established to be erosion resistant.

Construction Specifications

1. Level spreaders shall be installed under the direct supervision of the engineer.

2. Construct level lip on zero percent grade to insure uniform spreading of sediment-free runoff (converting channel flow to sheet flow).

3. Level spreader shall be constructed on undisturbed soil (not on fill).

4. A fiberglass matting erosion stop shall be placed vertically and at least six inches deep in a slit trench one foot back of the level lip and parallel with the lip. This erosion stop shall extend the entire length of the level lip and shall be trimmed after backfilling with tamped soil so that the upper edge is flush with the soil surface.

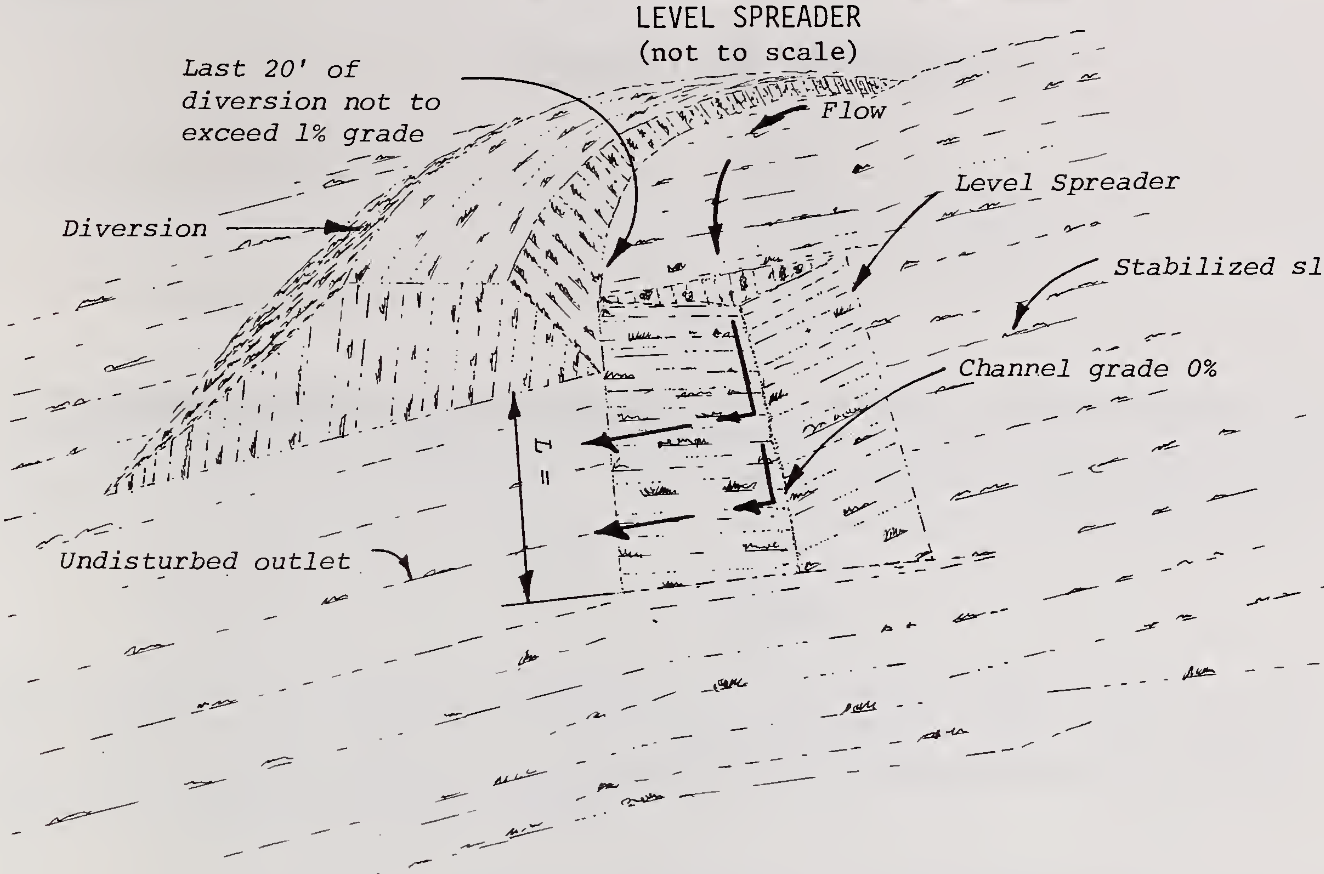
5. The entire level lip area shall be protected by placing two strips of jute or excelsior protective material as shown in the Standard Drawing LS-1.

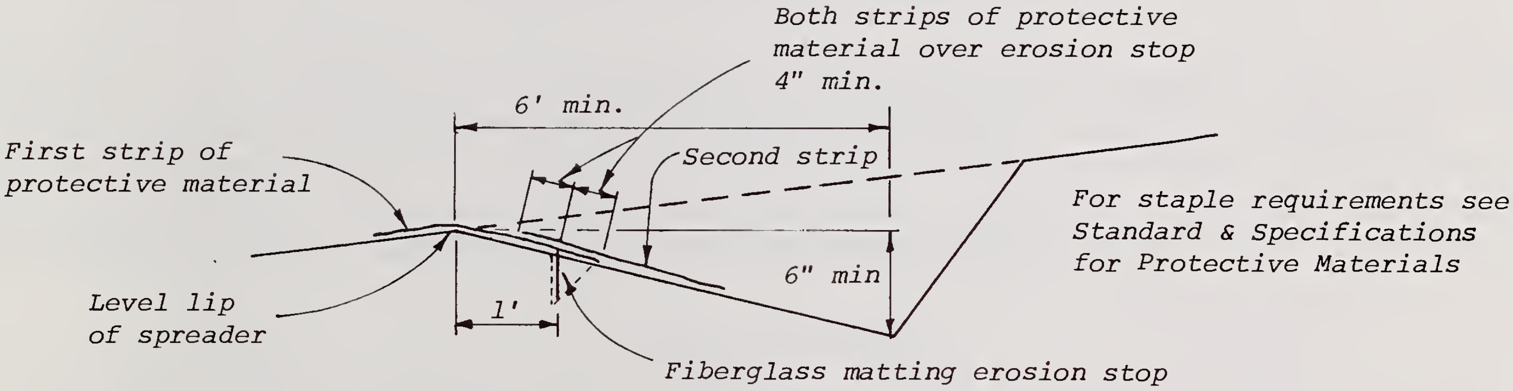
6. The entrance channel shall not exceed a 1% grade for at least 20 feet before entering spreader.

7. Storm runoff converted to sheet flow shall outlet onto stabilized areas. Water shall not be reconcentrated immediately below the point of discharge.

8. Periodic inspection and required maintenance shall be provided.

LEVEL SPREADER
(not to scale)





CROSS-SECTION

Construction Specifications

1. Level spreaders shall be installed under the direct supervision of the Engineer.
2. Construct level lip on zero percent grade to insure uniform spreading of sediment-free runoff (converting channel flow to sheet flow).
3. Level spreader shall be constructed on undisturbed soil (not on fill).
4. A fiberglass matting erosion stop shall be placed vertically and at least six inches deep in a slit trench one foot back of the level lip and parallel with the lip. This erosion stop shall extend the entire length of the level lip and shall be trimmed after backfilling with tamped soil so that the upper edge is flush with the soil surface.
5. The entire level lip area shall be protected by placing two strips of jute or excelsior protective material as shown in the Standard Drawing LS-1.
6. The entrance channel shall not exceed a 1% grade for at least 20 feet before entering spreader.
7. Storm runoff converted to sheet flow shall outlet onto stabilized areas. Water shall not be reconcentrated immediately below the point of discharge.
8. Periodic inspection and required maintenance shall be provided.

Standard Symbol L=

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE College Park, Md.	LEVEL SPREADER	Standard Drawing LS-1

STANDARD AND SPECIFICATIONS

FOR

STORM DRAIN OUTLET PROTECTION

Definition

Storm Drain Outlet Protection is the providing of deenergizing devices and erosion resistant channel sections between storm drain outlets and stable existing downstream channels. The channel sections may be rock-lined, vegetated, paved with concrete or otherwise made erosion resistant.

Purpose

The purpose of outlet protection is to convert pipe flow to channel flow, and reduce the velocity of the water consistent with the channel lining in order to convey the flow of water to a stable existing downstream channel without causing erosion.

Conditions Where Practice Applies

This practice applies to storm drain outlets, road culverts, paved channel outlets, etc. discharging into natural or constructed channels, which in turn discharge into existing streams or drainage systems. Analysis and appropriate treatment shall be done along the entire length of the flow path from the end of the conduit, channel or structure to the point of entry into an existing stream or publicly maintained drainage system.

Design Criteria

Show a plan view, profile, and cross-section of each channel reach between the storm drain outlet and the existing publicly maintained system or natural stream channel. Indicate the velocity for the following: 1) outlet (pipe, structure or paved channel), 2) riprap or paved apron section, and 3) each successive channel reach from the end of the apron to point of entry into existing drainage system or natural stream. Show on the plan the proposed method of stabilizing each channel reach consistent with computed velocities. The velocity at the end of a structure or channel reach must not exceed the allowable velocity for the next down-stream reach.

A channel reach is defined as a length of channel throughout which the hydraulic characteristics do not change. These include channel depth of flow, roughness, channel gradient, side slopes, bottom width, discharge rate and velocity. A natural stream channel is defined as a naturally formed channel through which the storm runoff would have flowed had there been no intervention by man and which is capable of conveying the peak rate of runoff after development without eroding.

Pipe Outlets (16,17,18)

All pipe outlets shall have a structurally-lined apron or other suitable deenergizing device immediately downstream from the outlet where the water can change from pipe flow to channel flow. The structually-lined apron shall meet the following criteria:

1. Bottom grade of 0.0%.

2. Side slopes of 2:1 or flatter.

3. The top of the sidewall shall extend at least one foot above maximum tailwater but no lower than two-thirds of the vertical conduit dimension above the conduit invert.

4. Invert elevation at the end is equal to or lower than the lowest elevation on the cross-section immediately downstream from the end of the apron. (i.e., No overfall at the end of the apron.)

5. Size of riprap and length of apron shall meet the criteria from Design of Outlet Protection in Appendix A-38 and riprap shall meet the Standard and Specifications for Riprap. Concrete paving may be substituted for the riprap. The median stone diameter, d_{50}, is the stone size which 50% of the riprap mixture, by weight, is larger than.

6. Where there is no well defined channel immediately downstream of the apron, the width of the end of the apron shall be as follows:

   for tailwater elevation greater than or equal to the elevation of the center of the pipe, $W = \text{diameter} + 0.4\ L_a$

   For tailwater elevation less than the elevation of the center of the pipe, $W = \text{diameter} + L_a$

   where L_a is the length of apron determined from the curves in Appendix A-38.

   Where there is a well defined channel immediately downstream of the apron, the width of the end of the apron shall be equal to the width of the channel section immediately downstream from the apron.

7. No bends or curves in the horizontal alignment of the pipe and the apron unless the structure is designed to adequately handle the flow.

Tailwater shall be determined by computing depth of flow in the channel reach immediately downstream from the apron by the use of Manning's equation.

Paved Channel Outlets

Paved channel sections shall meet the following criteria:

1. Velocity in the end of the paved section is no greater than the allowable velocity for the succeeding downstream section.

2. The downstream end of the invert of the paved section shall be no higher than the lowest point in the channel immediately downstream from the end of the paved section. (i.e., No overfall at the end of the apron)

3. The end of a paved channel shall merge smoothly with the next downstream channel section and this transition shall be accomplished within the paved channel. The bottom width of the end of the paved channel shall be at least as wide as the bottom width of the downstream channel. The maximum side divergence of a transition shall be 1 in 3F, where the Froude number, $F = \frac{V}{\sqrt{gd}}$ and V and d are velocity and depth of flow at the beginning of the transition and g is acceleration due to gravity, 32.2 ft. per sec ^{2}.

4. Bends or curves in the horizontal alignment of paved channels are not acceptable unless the Froude number, F, is 1.0 or less or the channel is specifically designed to contain the turbulent flow.

Channel Velocity in Unpaved Channels

Each channel reach having a natural, vegetated or riprap-paved bottom shall be checked for stability by calculating the flow velocity using Manning's equation and then assuring that the channel will handle that velocity without eroding. These computations will necessitate appropriate field surveys to determine cross-sections, grades, types of material in the channel and condition of the channel.

Channel Design Data

For the purpose of this Standard the roughness coefficient, n, used in calculations shall be as follows:

Channel Lining	n value
Asphaltic Concrete - machine finished	0.018
hand finished	0.022
Concrete-Float finish	0.015
Unfinished	0.017
Shotcrete, unfinished	0.022

Natural channels not completely lined with vegetation	0.025
Gabion mattresses	0.028
Fabriform - Filter point (waffled surface)	0.025
Riprap	See Appendix A-39
Vegetation	See Appendix to Standard & Specifications for Grassed Waterway, pp. A-36.14, 15.

Maximum flow velocities at design capacity shall be as follows: (14)

Channel Lining	Maximum Velocity, feet per second
Natural channels not completely lined with vegetation	
Sand and sandy loam	2.5
Silt loam	3.0
Sandy clay loam	3.5
Clay loam	4.0
Clay, fine gravel and graded loam to gravel	5.0
Graded silt to cobbles	5.5
Shale, hardpan and coarse gravels	6.0
Riprap	See the Standard & Specifications for Riprap
Vegetation	See the Standard & Specifications for Grassed Waterway

Right-of-Way

It has often been commonly accepted procedure to collect storm waters, convey it to the property line and then "turn it loose". There was little or no concern for erosion or for drainage easements on property owned by others. The purpose of this Standard and Specification is to prevent erosion by storm runoff whether on or off the property being developed. It will therefore be necessary to comply with all legal requirements with respect to property

owned by others. As a minimum, all sediment control plans that require any offsite grading, construction or other improvements shall be accompanied by a proper legal easement.

Construction Specifications

1. For natural or vegetated channels, see the Standard and Specifications for Grassed Waterway.

2. Aprons at the end of pipe or lined channel outlets shall meet the following criteria:

   a. Bottom grade shall be 0.0%

   b. Side slopes 2:1 or flatter

   c. Sidewalls shall extend up as shown on the plans but not less than two-thirds the pipe diameter.

   d. There shall be no overfall from the end of the apron to the surface of the receiving channel. The area to be paved or riprapped shall be undercut so that the invert of the apron shall be at the same grade (flush) with the surface of the receiving channel. The apron shall have a cutoff or toe wall at the downstream end.

   e. Apron dimensions and riprap size or concrete thickness must be as shown on the plans.

   f. The width of the end of the apron shall be equal to the bottom width of the receiving channel.

   g. The placing of fill, either loose or compacted in the receiving channel shall not be allowed.

   h. No bends or curves in the horizontal alignment of the apron will be permitted.

3. Paved channel sections shall meet the following criteria:

   a. Side slopes, dimensions, grades, etc. shall be as shown on the plans.

   b. There shall be no overfall from the end of the paving to the surface of the receiving channel.

   c. Riprap size or concrete thickness, joint details, etc. shall be as shown on the plans.

   d. The end of paved sections shall be as wide as the receiving channel and the transition between the two channels shall be smooth.

   e. The placing of fill, either loose or compacted in the receiving channel shall not be allowed.

   f. Bends or curves in the horizontal alignment of paved channels are not acceptable unless shown on the plans and the radius of curvature must be the same as shown on the plans.

4. Riprap construction shall comply with the Standard and Specifications for Riprap.

APPENDIX A-38

DESIGN OF OUTLET PROTECTION

Outlet protection as presented here is a level apron of sufficient length and flare such that the expanding flow (from pipe or conduit to channel) loses sufficient velocity and energy that it will not erode the next downstream channel reach. The design curves are based on circular conduits flowing full. The curves provide the apron size and if riprap is to be used, the minimum d_{50} size for the riprap. There are two curves, one for a low or minimum tailwater condition and the other a high or maximum tailwater condition. The minimum condition applies to a tailwater surface elevation less than the center of the pipe whereas the maximum condition applies to a tailwater surface elevation equal to or higher than the center of the pipe.

The first requirement in using this procedure is to determine the tailwater condition as required in the Standard and Specifications. Then, for circular conduits, enter the appropriate chart with the discharge and the pipe diameter to find the riprap size and apron length. Then calculate apron width.

Example 1:

A circular conduit is flowing full
Q = 280 cfs, diam. = 66", and tailwater (surface) is 2 ft. above pipe invert.

This is a minimum tailwater condition.
Read d_{50} = 1.2', and apron length = 38'
Apron width = diam + L_a = 38 + 5.5 = 43.5'
Maximum stone size in the riprap mixture = 1.5 x d_{50} = 1.5 x 1.2 = 1.8'.

The curves may also be used for the design of outlet protection for rectangular conduits but the procedure is slightly different. Depth of flow and velocity are the two flow parameters to be used. Enter the lower set of curves with velocity and depth (using the diameter curves for depth), then read to the right to find d_{50} and up and left for the length of apron. To find the apron width substitute conduit width for diameter in the apron width equations.

Example 2:

A concrete box 5.5' x 10' is flowing 5.0' deep, Q = 600 cfs and tailwater surface 5' above invert (Max. tailwater condition).

$$V = \frac{Q}{A} = \frac{600}{5.0 \times 10} = 12 \text{ fps}$$

At the intersection of the curve d=60" and V=12 fps, read d_{50} = 0.4'.

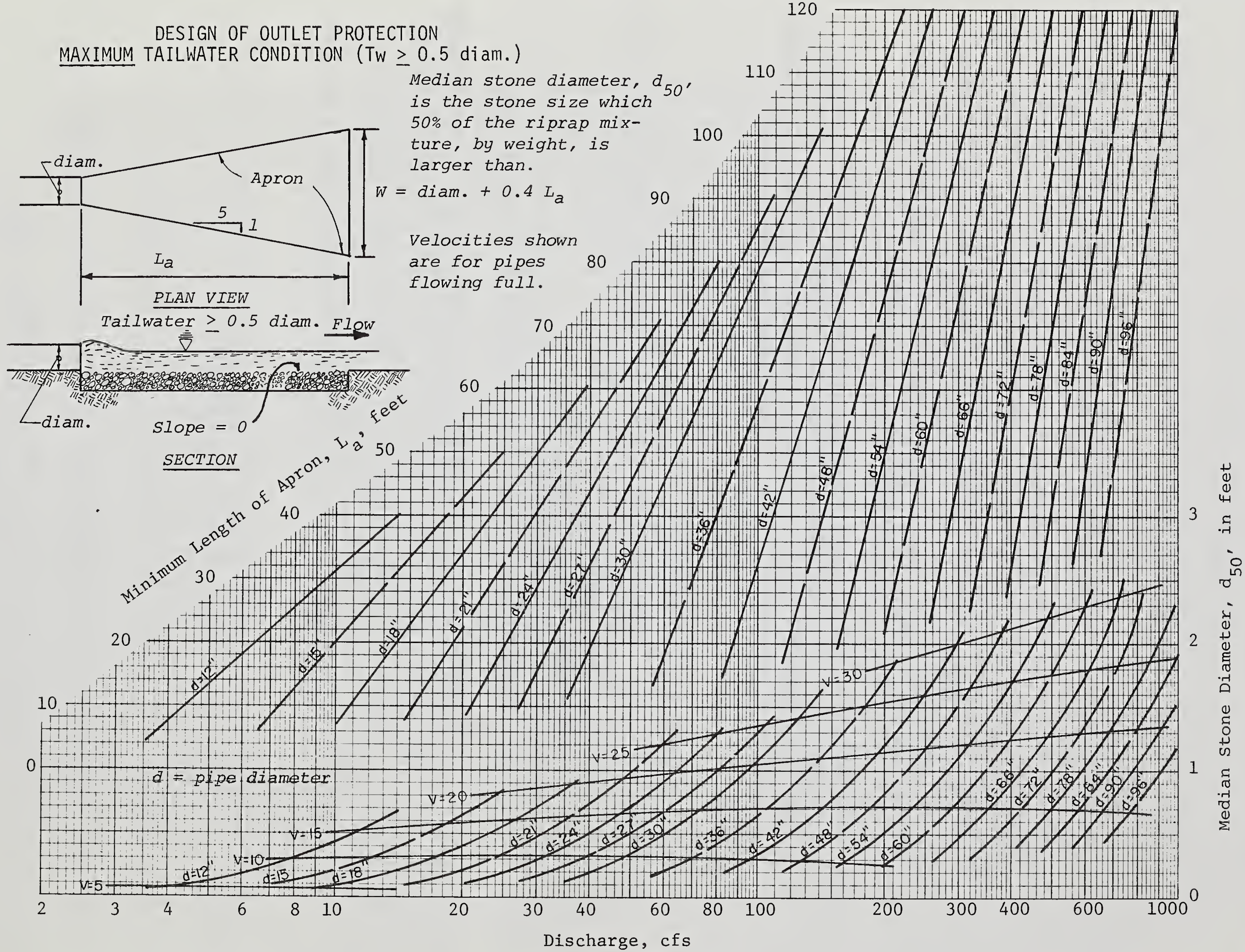
Then reading up to the d = 60" curve, read apron length = 40'.
Apron width, W = conduit width + 0.04 L_a = 10+(0.4)(40) = 26',
Largest stone size = 0.4 x 1.5 = 0.6' or 7"

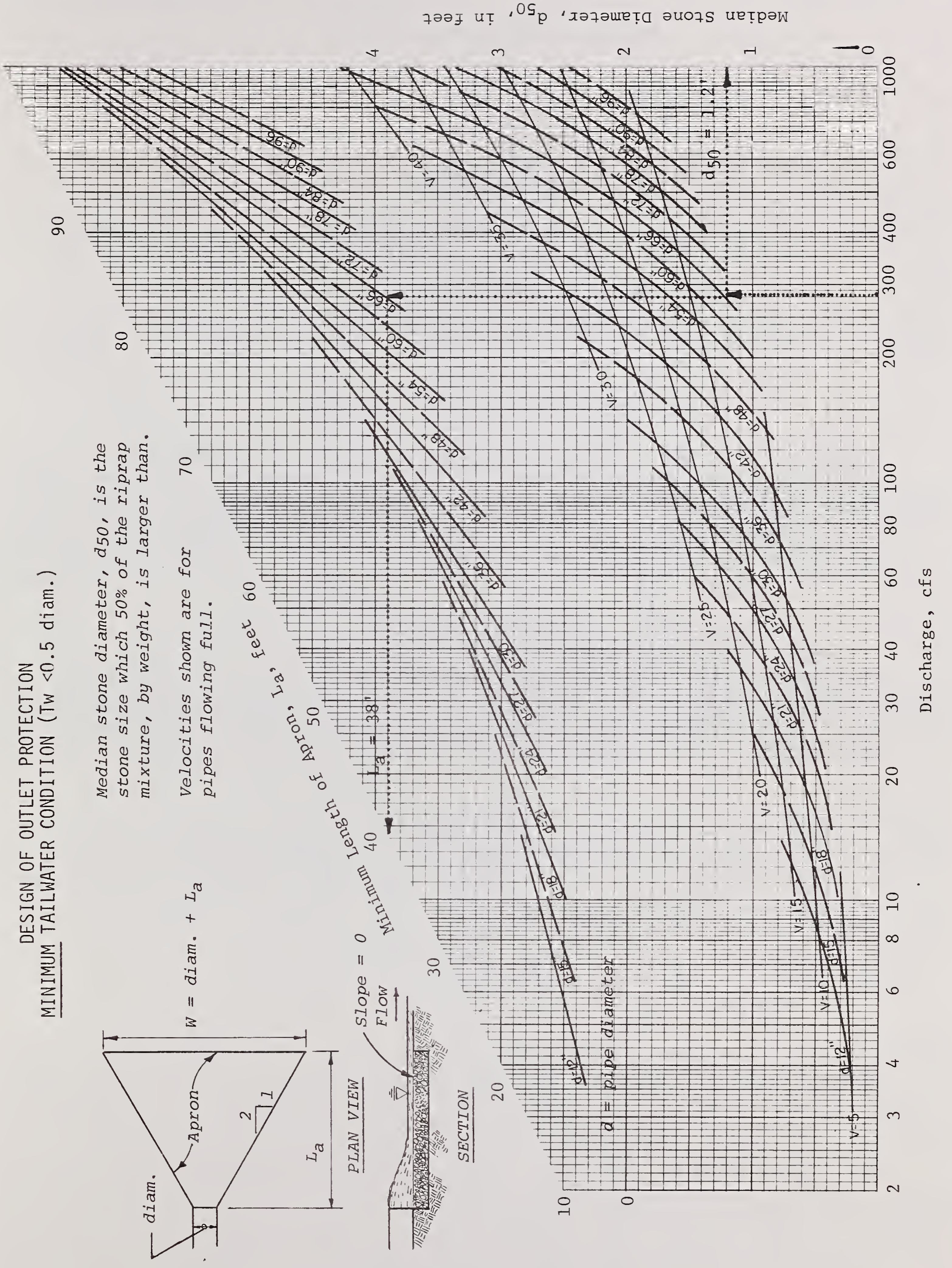
DESIGN OF OUTLET PROTECTION
MAXIMUM TAILWATER CONDITION (Tw ≥ 0.5 diam.)

Median stone diameter, d_{50}, is the stone size which 50% of the riprap mixture, by weight, is larger than.

W = diam. + 0.4 L_a

Velocities shown are for pipes flowing full.




DESIGN OF OUTLET PROTECTION
MINIMUM TAILWATER CONDITION (Tw <0.5 diam.)
Median stone diameter, d50, is the stone size which 50% of the riprap mixture, by weight, is larger than.
Velocities shown are for pipes flowing full.
W = diam. + La
diam.
Apron
2
1
La
PLAN VIEW
Slope = 0
Flow
SECTION
Minimum Length of Apron, La, feet
La = 38'
Median Stone Diameter, d50, in feet
d50 = 1.2'
Discharge, cfs
d = pipe diameter
V=5
V=10
V=15
V=20
V=25
V=30
V=35
V=40
d=12"
d=15"
d=18"
d=21"
d=24"
d=27"
d=30"
d=36"
d=42"
d=48"
d=54"
d=60"
d=66"
d=72"
d=78"
d=84"
d=90"
d=96"
2
3
4
6
8
10
20
30
40
60
80
100
200
300
400
600
1000
0
1
2
3
4
10
20
30
40
50
60
70
80
90

STANDARD AND SPECIFICATIONS

FOR

RIPRAP

Definition

A layer of loose rock or aggregate placed over an erodible soil surface.

Purpose

The purpose of riprap is to protect the soil surface from the erosive forces of water.

Condition Where Practice Applies

This practice applies to soil-water interfaces where the soil conditions, water turbulence and velocity, expected vegetative cover and groundwater conditions are such that the soil may erode under the design flow conditions. Riprap may be used, as appropriate, at such places as storm drain outlets, channel banks and/or bottoms, roadside ditches, drop structures and shore-lines.

Design Criteria

The minimum design discharge for channels and ditches shall be the peak discharge from a 10-year frequency rainfall event based on maximum watershed development during the life of the structure. The roughness coefficient, n, used for determining flow on the constructed riprap surface shall be as given by Curve 1 in the Appendix.

For design of riprap lined channels, refer to the National Cooperative Highway Research Program Report No. 108, entitled "Tentative Design Procedure for Riprap-Lined Channels." This is a procedure for determining a design stone size such that the stone is stable under the design flow conditions with a reasonable factor of safety. The design stone size used in this Standard and Specification is the d_{50} or median stone diameter which is defined as the stone size such that 50 percent of the mixture, by weight, is larger than that size. The riprap design procedure is given in the Appendix. (19)

Erosive forces of flowing water is greater in bends than in straight channels. Riprap size for bends in the channel shall be computed according to the procedure in the Appendix. If the riprap size (d_{50}) computed for bends is less than 10 percent greater than the riprap size (d_{50}) for straight channels, then the riprap size for straight channels shall be considered to be of adequate size, otherwise the larger riprap size shall be used in the bend. This allowance is made in order to minimize the number of riprap sizes required. No more than two riprap sizes should be used on any single contract in order to minimize construction problems caused by too many sizes. The riprap size to be used in a bend shall extend upstream from the point of curvature

and downstream from the point of tangency a distance equal to five times the channel bottom width. (Length = 5b). This riprap size shall extend across the bottom and up both sides of the channel.

For erosion of tidal shores see the U. S. Army Corps of Engineers "Shore Protection Manual" (20).

Riprap

The riprap shall be composed of a well-graded mixture down to the one-inch size particle such that 50% of the mixture by weight shall be larger than the d_{50} size as determined from the design procedure. A well-graded mixture as used herein is defined as a mixture composed primarily of the larger stone sizes but with a sufficient mixture of other sizes to fill the progressively-smaller voids between the stones. The diameter of the largest stone size in such a mixture shall be considered to be 1.5 times the d_{50} size. The riprap size as shown on the plans and specifications or for other construction purposes shall be the size of the largest stone in the mixture, i.e. 1.5 x d_{50}. The minimum thickness of the riprap layer shall be 1.5 times the maximum stone diameter but not less than six inches. The riprap shall extend up the banks to a height equal to maximum depth of flow or to a point where vegetation can be established to adequately protect the channel.

In channels where there is no riprap or paving in the bottom, the toe of the bank riprap shall extend below the channel bottom a distance at least 1.5 times the maximum stone size but in no case less than one foot. The only exception to this would be in the event that there is a non-erodible hard rock bottom. The channel bank shall not be steeper than 2.0 horizontal to 1 vertical.

The designer after determining the riprap size that will be stable under the flow conditions shall consider that size to be a minimum size and then, based on riprap gradations actually available in the area select the size or sizes that equal or exceed the minimum size. The possibility of damage by children shall be considered in selecting a riprap size, especially if there is nearby water to toss the stones into.

Filter

A filter is a layer of material placed between the riprap and the underlying soil surface to prevent soil movement into and through the riprap.

Riprap shall have a filter placed under it when either of the following conditions exist:

1. The riprap is not well graded down to the one-inch size particle.

2. Riprap is placed on the side slopes of a channel and the soil is sand-size or finer with a plasticity index, PI, less than 10. This requirement applies to slopes having this soil in lenses or layers greater than three inches in thickness.

A filter can be of two general forms. One is a single layer of plastic filter cloth manufactured for that express purpose. The plastic filter cloth shall be woven of polypropylene monofilament yarns and shall be equivalent to "Poly-Filter X" as manufactured by Carthage Mills, Inc. Cinncinnati, Ohio. Another is a properly graded layer of sand, gravel, or stone.

The criteria for the design of an aggregate filter is as follows:

$$\frac{d_{15}\ \text{Riprap}}{d_{85}\ \text{Filter}} \leq 5 \qquad \frac{d_{15}\ \text{Filter}}{d_{85}\ \text{Base}} \leq 5$$

in which d_{15} and d_{85} is the size of base, filter or riprap material of which 15 and 85 percent respectively is finer. The base means the soil layer underneath the filter. The filter shall be graded down to sand-size particles. Riprap that is 12" and larger shall not be dumped directly onto the plastic filter cloth since it may tear or displace the filter cloth. Instead, a 4-inch minimum thickness blanket of gravel shall be placed over the filter cloth or the riprap shall be placed directly on the filter cloth by hand or by the bucket of the equipment. Side slopes shall be 2:1 or flatter in order for the gravel not to slide down the filter cloth before placing the riprap.

Soil Size Classification

Soil sizes given herein are according to the Unified Soil Classification System as shown below.

Soil	Sieve Size
Gravel	Smaller than 3" and larger than #4 (Approx. 1/4")
Sand	Smaller than #4 and larger than #200 (0.074 mm)

Quality

Stone for riprap shall consist of field stone or rough unhewn quarry stone of approximately rectangular shape. The stone shall be hard and angular and of such quality that it will not disintegrate on exposure to water or weathering and it shall be suitable in all other respects for the purpose intended. The specific gravity of the individual stones shall be at least 2.5.

Rubble concrete may be used provided it has a density of at least 150 pounds per cubic foot, and otherwise meets the requirements of this Standard and Specification.

Construction Specifications

1. The subgrade for the riprap or filter shall be prepared to the required lines and grades. Any fill required in the subgrade shall be compacted to a density approximating that of the surrounding undisturbed material.

2. The rock or gravel shall conform to the specified grading limits when installed respectively in the riprap or filter.

3. Plastic filter cloth shall be protected from punching, cutting or tearing. Any damage other than an occasional small hole shall be repaired by placing another piece of cloth over the damaged part or by completely replacing the cloth. All overlaps whether for repairs or for joining two pieces of cloth shall be a minimum of one foot.

4. The stone for the filter and riprap may be placed by equipment. Both filter and riprap shall each be constructed to the full course thickness in one operation and in such a manner to avoid displacement of the underlying materials. The stone for filter and riprap shall be delivered and placed in a manner that will insure that the filter and riprap each shall be reasonably homogeneous with the smaller stones and spalls filling the voids between the larger stones. Riprap shall be placed in a manner to prevent damage to the filter blanket. Hand placing will be required to the extent necessary to prevent damage to the permanent works.

APPENDIX A-39

DESIGN PROCEDURE FOR RIPRAP-LINED CHANNELS

This design of riprap-lined channels is from the National Cooperative Highway Research Program Report No. 108, entitled "Tentative Design Procedure for Riprap-Lined Channels." It is based on the tractive force method and covers the design of riprap in two basic channel shapes, trapezoidal and triangular. (19)

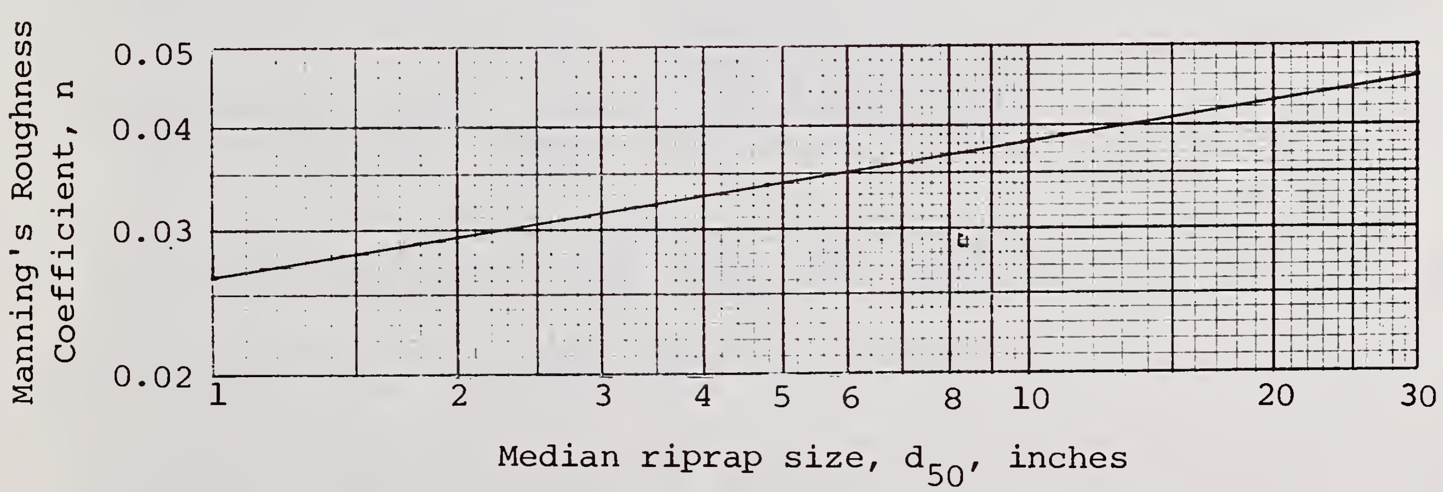
NOTE: This procedure is for the uniform flow in channels and is not to be used for design of riprap deenergizing devices immediately downstream from such high velocity devices as pipes and culverts. See the Standard and Specification for Storm Drain Outlet Protection.

The method in Report No. 108 (design procedure beginning on p. 18) gives a simple and direct solution to the design of trapezoidal channels including channel carrying capacity, channel geometry and the riprap lining. The publication is a very good reference and design aid.

The procedure presented in this Appendix is based on the assumption that the channel is already designed and the remaining problem is to determine the riprap size that would be stable in the channel. The designer would first determine the channel dimensions by the use of Manning's equation. The n value for use in Manning's equation is estimated by estimating a riprap size and then determining the corresponding n value for the riprapped channel from Curve 1, below.

Curve 1 - Manning's "n" for Riprap-Lined Channels

$n = 0.0395(d_{50})^{1/6}$



When the channel dimensions are known the riprap can be designed (or an already completed design may be checked) as follows:

Trapezoidal Channels

1. Calculate the b/d ratio and enter curve 2 to find the P/R ratio.

2. Enter curve 3 with S_b, Q, and P/R to find median riprap diameter, d_{50}, for straight channels.

3. Enter curve 1 to find the actual n value corresponding to the d_{50} from step 2. If the estimated and actual n values are not in reasonable agreement another trial must be made.

4. For channels with bends, calculate the ratio B_s/R_o, where B_s is the channel surface width and R_o is the radius of the bend. Enter curve 4 and find the bend factor, F_B. Multiply the d_{50} for straight channels by the bend factor to determine riprap size to be used in bends. If the d_{50} for the bend is less than 1.1 times the d_{50} for the straight channel, then the size for straight channel may be used in the bend, otherwise the larger stone size calculated for the bend shall be used. The riprap shall extend across the full channel section and shall extend upstream and downstream from the ends of the curve a distance equal to five times the bottom width.

5. Enter curve 5 to determine maximum stable side slope of riprap surface.

Triangular Channels

1. Enter curve 3A with S_b, Q and Z and find the median riprap diameter, d_{50}, for straight channels.

2. Enter curve 1 to find the actual n value. If the estimated and actual n values are not in reasonable agreement another trial must be made.

3. For channels with bends, see step 4 under Trapezoidal channels.

The riprap size to be specified on the plans shall be the maximum stone size in the mixture which shall be 1.5 times the d_{50}. The thickness of the riprap layer is 1.5 times the maximum stone size, but not less than six inches. Freeboard shall be added to the channel depth and shall be not less than 0.2 times the depth of flow or 0.3 feet, whichever is greater.

Example:

Given:

Trapezoidal channel

$Q = 100$ cfs
$S = 0.01$ ft/ft.
Side slopes = 2.5:1
Mean bend radius, $R_o = 25'$
$n = .033$ (estimated and used to design the channel to find that $b = 6'$ and $d = 1.8'$)
Type of rock available is crushed stone.

Solution:

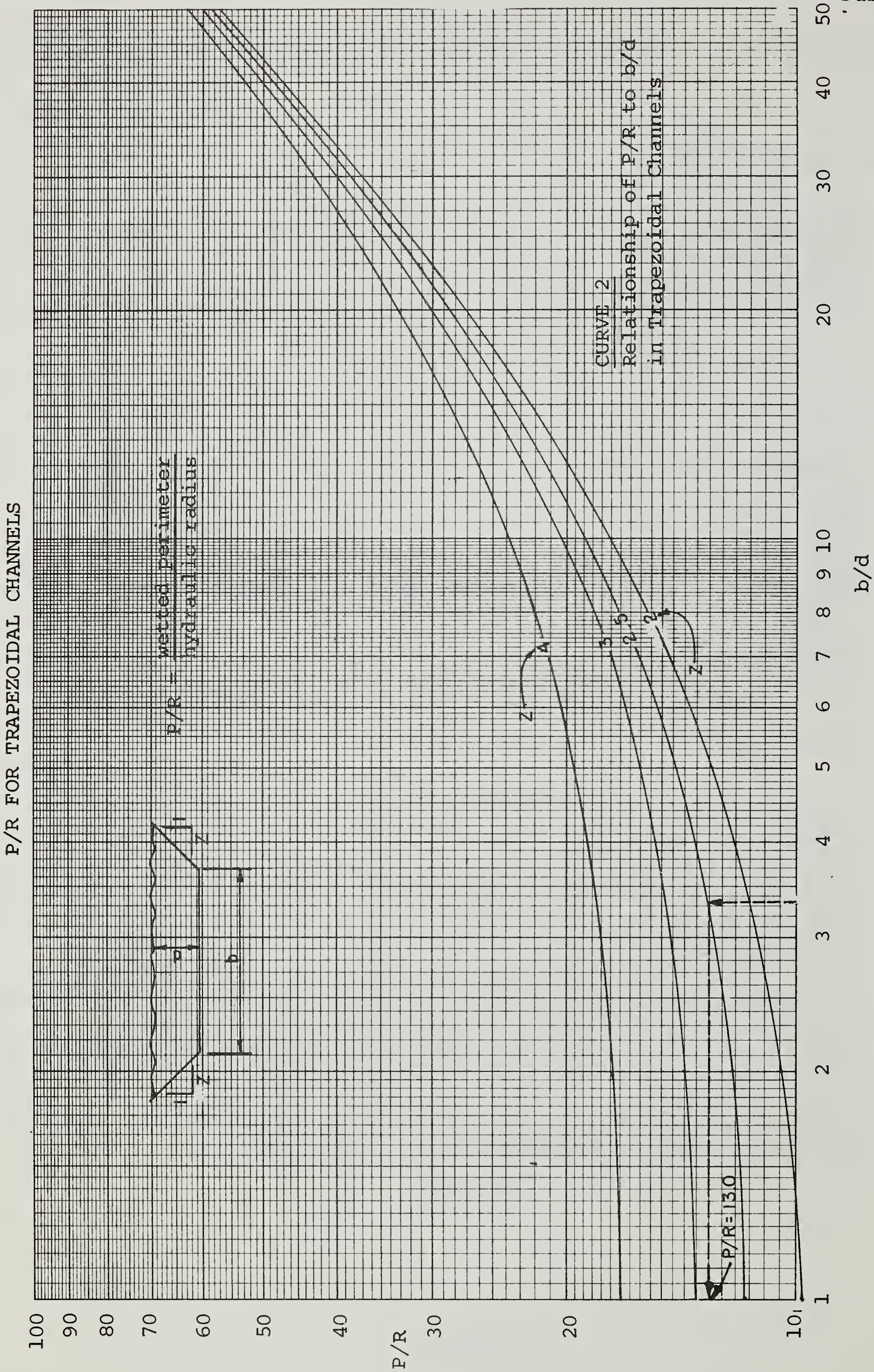
<u>Straight channel reach</u>

$b/d = 6/1.8 = 3.33$
from curve 2, $P/R = 13.0$
from curve 3, $d_{50} = 3.4"$
from curve 1, n (actual) = 0.032, which is reasonably close to the estimated n of 0.033.
Maximum riprap size = 1.5 x 3.4 = 5.1"
Riprap thickness = 1.5 x 5.1 = 7.7"
<u>Use 5" as maximum riprap size and 8" as riprap layer thickness.</u>

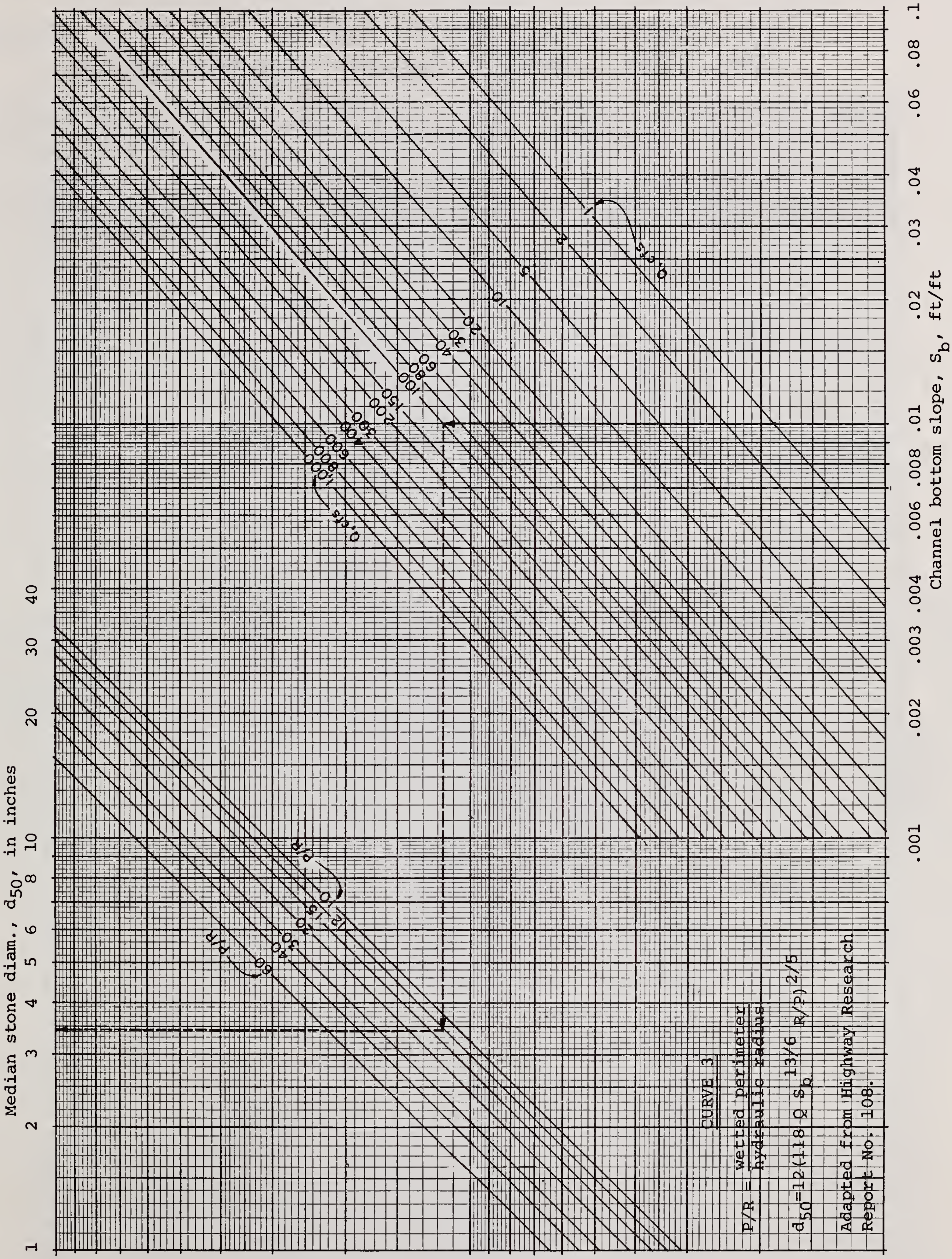
<u>Channel bend</u>

$B_s = b + 2zd = 6 + (2)(2.5)(1.8) = 15'$
$B_s/R_o = 12/25 = 0.60$
from curve 4, $F_B = 1.33$
$F_B = 1.33 > 1.1$, therefore the bend factor must be used.
Riprap size in bend, $d_{50} = 3.4 \times 1.33 = 4.52"$
Max. riprap size in bend = 4.52 x 1.5 = 6.78"
Riprap thickness = 10.2"
<u>Use 7" for max. riprap size and 10" for riprap layer thickness.</u>
The heavier riprap for the bend shall extend upstream and downstream from the ends of the bend a distance of (5)(6) = 30 feet.
From curve 5, it can be found that the riprap for $d_{50} = 3.4"$ and 4.52" will both be stable on a 2.5:1 side slope.

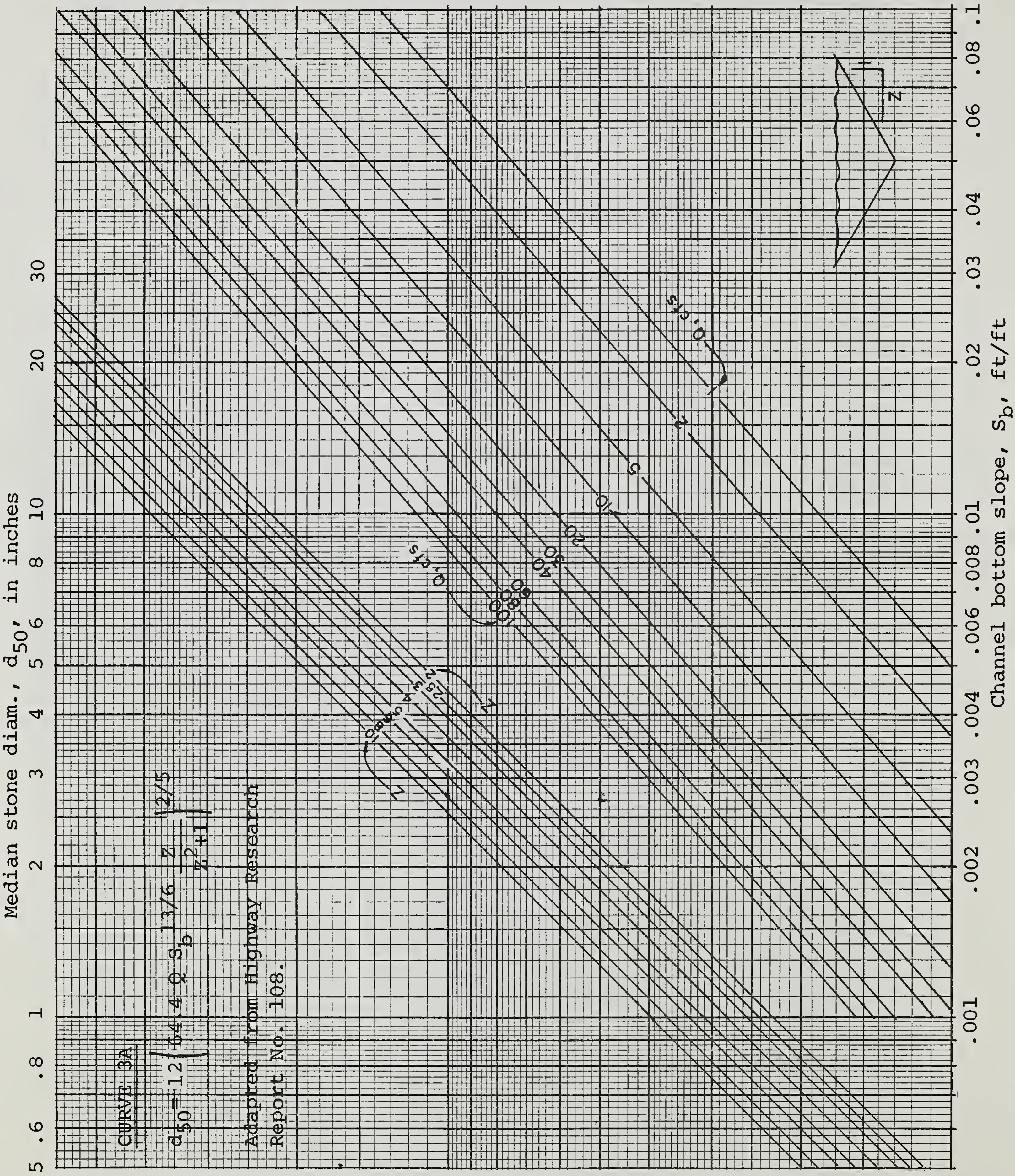
Freeboard = (0.2)(1.8) = .36' but not less than 0.3'
Therefore, minimum freeboard is 0.36'. <u>Use 0.4'</u>


P/R FOR TRAPEZOIDAL CHANNELS
P/R = wetted perimeter / hydraulic radius
CURVE 2
Relationship of P/R to b/d
in Trapezoidal Channels
P/R
b/d
Z
4
3
2.5
2
P/R=13.0
d
b
1
1
Z
100
90
80
70
60
50
40
30
20
10
1
2
3
4
5
6
7
8
9
10
20
30
40
50

MEDIAN RIPRAP DIAMETER FOR STRAIGHT TRAPEZOIDAL CHANNELS



MEDIAN RIPRAP DIAMETER FOR STRAIGHT TRIANGULAR CHANNELS



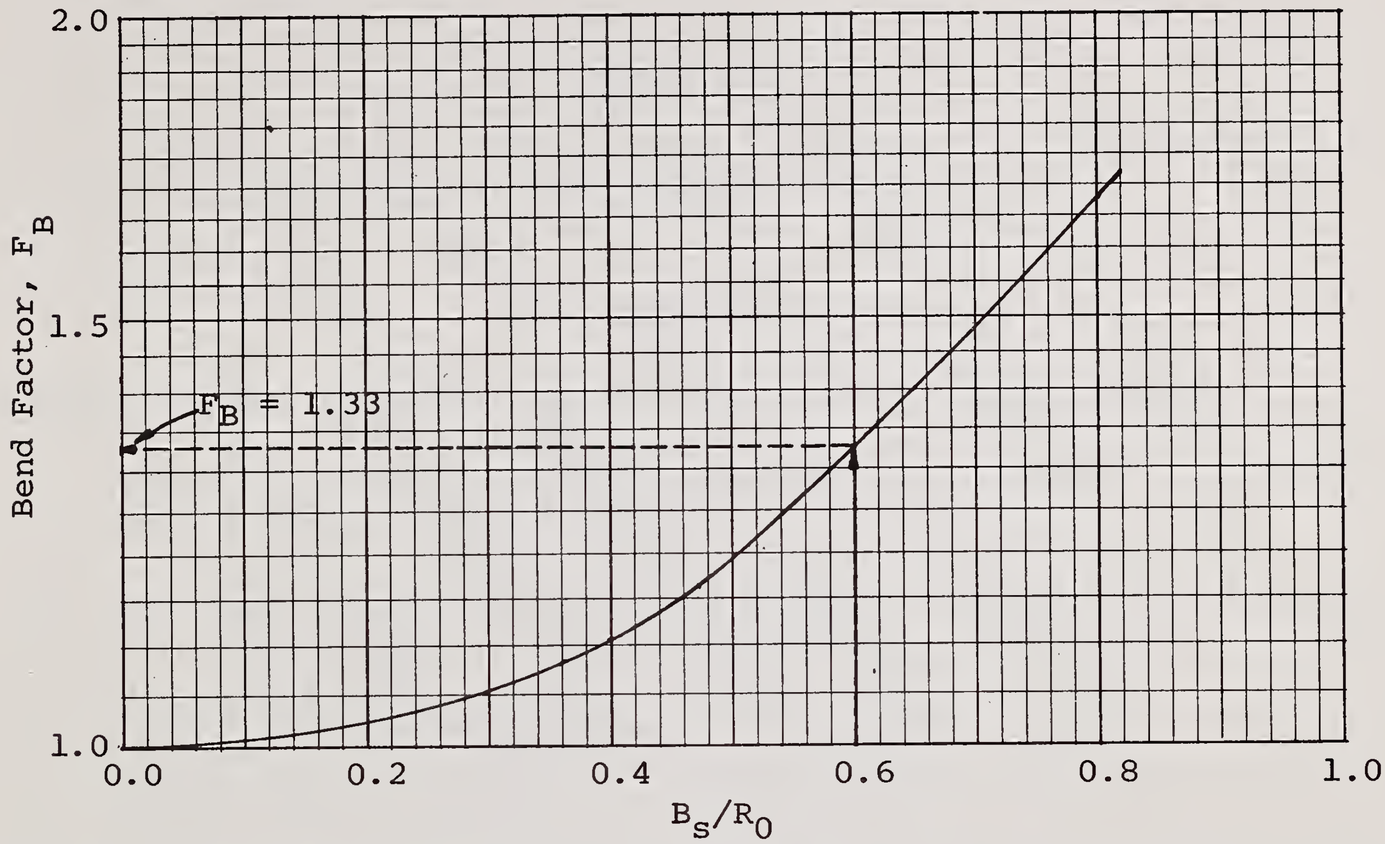
CURVE 4 - RIPRAP SIZE CORRECTION FACTOR FOR FLOW IN CHANNEL BENDS

d_{50}(for bend) = d_{50}(for straight) X F_B

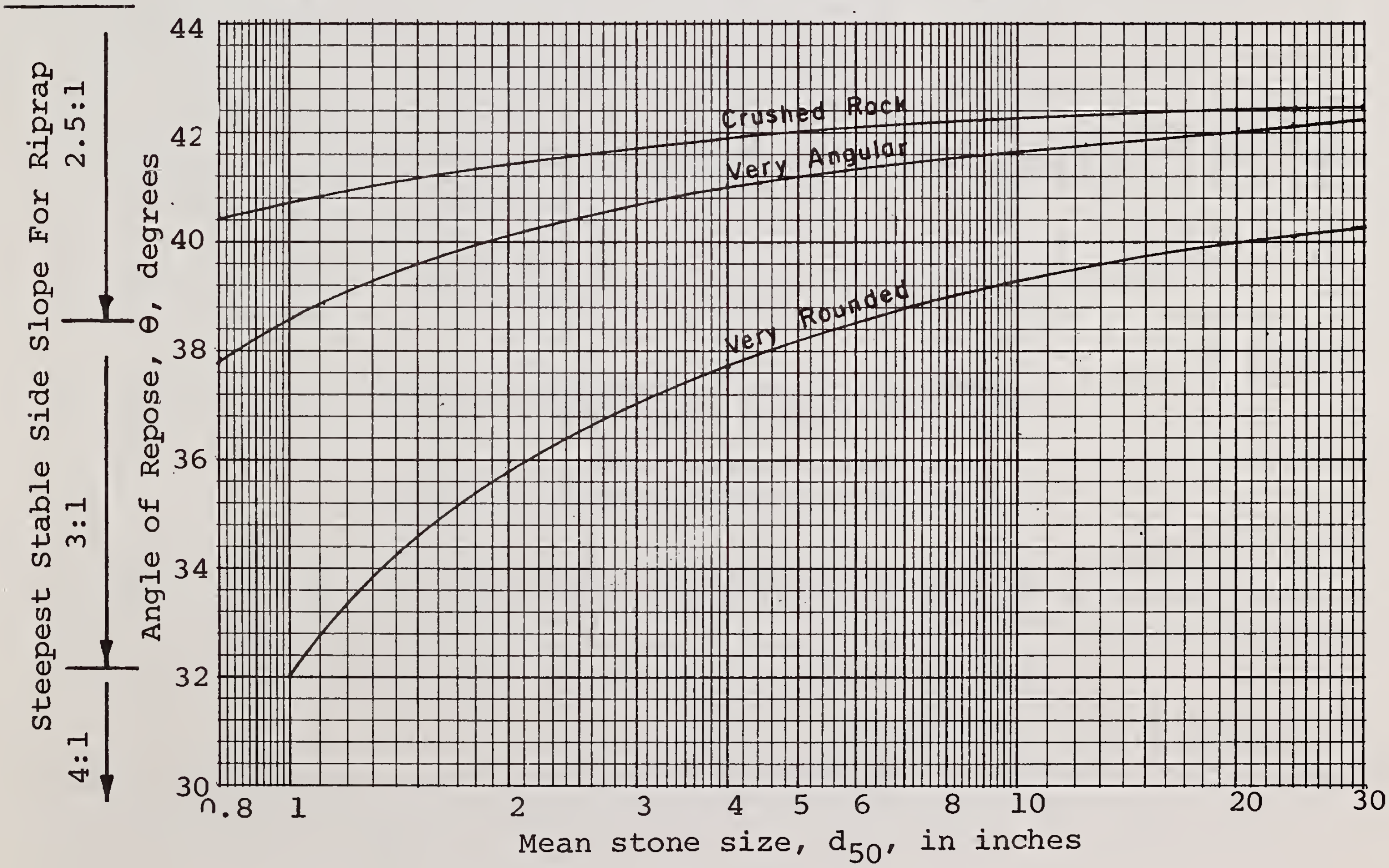
B_s = channel surface width

R_o = mean radius of bend

Adapted from Highway Research Report No. 108.



CURVE 5 - MAXIMUM RIPRAP SIDE SLOPE WITH RESPECT TO RIPRAP SIZE



STANDARD AND SPECIFICATIONS

FOR

SUBSURFACE DRAIN

Definition

A conduit, such as pipe or tubing, installed beneath the ground surface which intercepts, collects, and/or conveys drainage water.

Purpose

A subsurface drain may serve one or more of the following purposes:

1. Improve the soil environment for vegetative growth by regulating the water table and groundwater flow.

2. Intercept and prevent groundwater movement into a wet area and to handle base flow for grassed waterways.

3. Relieve artesian pressures.

4. Remove surface runoff.

5. Provide internal drainage of slopes to improve their stability and reduce erosion.

6. Provide internal drainage behind bulkheads, retaining walls, etc.

7. Replace existing subsurface drains that are interrupted or destroyed by construction operations.

8. Provide subsurface drainage for dry storm water management structures.

9. Improve dewatering of sediment in sediment basins. (See Standard and Specifications for Sediment Basins).

Conditions Where Practice Applies

Subsurface drains are used where lowering or controlling groundwater or surface runoff is required. The soil shall have enough depth and permeability to permit installation of an effective system. This standard does not apply to storm drainage systems or foundation drains.

An outlet for the drainage system shall be available, either by gravity flow or by pumping. The outlet shall be adequate for the quantity of water to be discharged without causing damage above or below the point of discharge and shall comply with all state and local laws.

Design Criteria

Required Capacity of Drains

The required capacity shall be determined by one or more of the following:

1. Where subsurface drainage is to be uniform over an area through a systematic pattern of drains, a drainage coefficient of 1 inch to be removed in 24 hours shall be used. (See Drain Charts in the Appendix).

2. Where subsurface drainage is to be by a random system a minimum inflow rate of 1.5 cfs per 1,000 feet of line shall be used to determine the required capacity.

   For interceptor subsurface drains on sloping land, increase the inflow rate as follows:

Land Slopes	Increase Inflow Rate By
2 - 5 percent	10 percent
5 -12 percent	20 percent
over 12 percent	30 percent

3. Additional design capacity must be provided if surface water is allowed to enter the system.

Size of Subsurface Drain

The size of subsurface drains shall be determined from the Drain Charts found in the Appendix. All subsurface drains shall have a nominal diameter which equals or exceeds four (4) inches.

Depth and Spacing

The minimum depth of cover of subsurface drains shall be 24 inches where possible. The minimum depth of cover may be reduced to a minimum of 12 inches where it is not possible to attain the 24 inch depth and where the drain is not subject to damage by equipment loading or frost action. Roots from some types of vegetation can plug drains as the drains get closer to the surface.

The spacing of drain laterals will be dependent on the permeability of the soil, the depth of installation of the drains and degree of drainage required. Generally, drains installed 36 inches deep and spaced 50 feet center-to-center will be adequate. For more specific information see the "Maryland Drainage Guide" (see Reference List).

Minimum Velocity and Grade

The minimum grade for subsurface drains shall be 0.10 percent. Where surface water enters the system a velocity of not less than 2 feet per second shall

be used to establish the minimum grades. Provisions shall be made for preventing debris or sediment from entering the system by means of filters or collection and periodic removal of sediment from installed traps.

Materials for Subsurface Drains

Acceptable subsurface drain materials includes perforated, continuous closed joint conduits of polyethylene plastic, concrete, corrugated metal, asbestos-cement, bituminized fiber and poly vinyl chloride.

The conduit shall meet strength and durability requirements of the site.

Loading

The allowable loads on subsurface drain conduits shall be based on the trench and bedding conditions specified for the job. A factor of safety of not less than 1.5 shall be used in computing the maximum allowable depth of cover for a particular type of conduit.

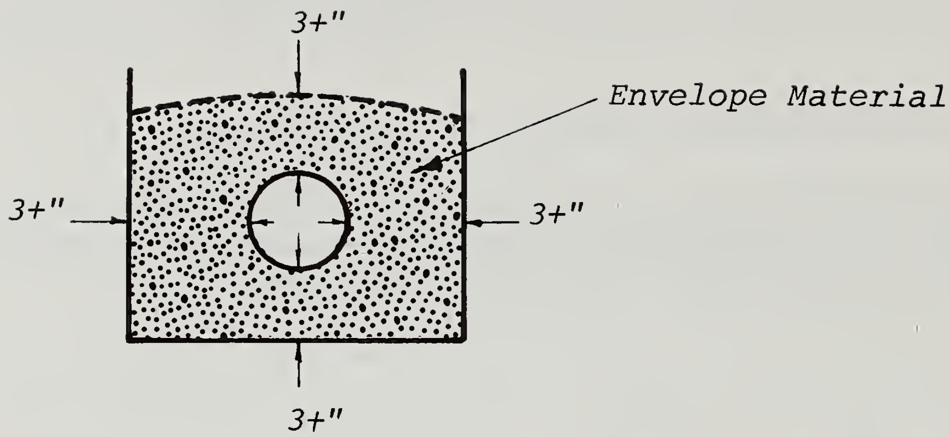
Envelopes and Envelope Material

Envelopes shall be used around subsurface drains for proper bedding of the conduit. Not less than three inches of envelope material shall be used for sand-gravel envelopes. Where necessary to improve the characteristics of flow of groundwater into the conduit, more envelope material may be required.

Envelope material shall be placed to the height of the uppermost seepage strata. Behind bulkheads and retaining walls, it shall go to within twelve inches of the top of the structure. This does not cover the design of filter materials where needed.

Materials used for envelopes shall not contain materials which wlll cause an accumulation of sediment in the conduit or render the envelope unsuitable for bedding of the conduit. Envelope materials shall consist of sand-gravel material, all of which shall pass a 1-1/2 inch sieve, 90 to 100 percent shall pass a 3/4 inch sieve, and not more than 10 percent shall pass a No. 60 sieve. (Maryland State Highway Administration size No. 7 meets this gradation).

The conduit shall be placed and bedded in a sand-gravel envelope. A minimum of 3 inches depth of envelope material shall be placed on the bottom of a conventional trench. The conduit shall be placed on this and the trench completely filled with envelope material to minimum depth of 3 inches above the conduit.



Soft or yielding soils under the drain shall be stabilized where required and lines protected from settlement by adding gravel or other suitable material to the trench, by placing the conduit on plank or other rigid support, or by using long sections of perforated or watertight pipe with adequate strength to insure satisfactory subsurface drain performance.

Auxiliary Structure and Subsurface Drain Protection

The outlet shall be protected against erosion and undermining of the conduit, against damaging periods of submergence and against entry of rodents or other animals into the subsurface drain. (See Drawing for Animal Guard in the Appendix).

A continuous 10 foot section of corrugated metal, cast iron, or steel pipe without perforations shall be used at the outlet end of the line and shall outlet above the normal elevation of low flow in the outlet ditch or above mean high tide in tidal areas. No envelope material shall be used around the 10 foot section of pipe. Two-thirds of the pipe shall be buried in the ditch bank and the cantilevered section shall extend to a point above the toe of the ditch side slope or the side slope shall be protected from erosion.

Conduits under roadways and embankments shall be watertight and designed to withstand the expected loads.

Where surface water is to be admitted to subsurface drains, inlets shall be designed to exclude debris and prevent sediment from entering the conduit. Lines flowing under pressure shall be designed to withstand the resulting pressures and velocity of flow. (See Surface Water Inlet drawing in the Appendix). Surface waterways shall be used where feasible.

The upper end of each subsurface drain line shall be capped with a tight fitting cap of the same material as the conduit or other durable material unless connected to a structure.

CONSTRUCTION SPECIFICATIONS

1. Deformed, warped, or otherwise damaged pipe or tubing shall not be used.

2. All subsurface drains shall be laid to a uniform line and covered with envelope material. The pipe or tubing shall be laid with the perforations down and oriented symmetrically about the vertical center line. Connections will be made with manufactured functions comparable in strength with the specified pipe or tubing unless otherwise specified. The method of placement and bedding shall be as specified on the drawing.

3. Envelope material shall be a sand-gravel material all of which shall pass the 1-1/2 inch sieve, 90 to 100 percent shall pass the 3/4 inch sieve, and not more than ten percent shall pass the No. 60 sieve. Envelope material meeting the Maryland State Highway Administration's size No. 7 will meet the above gradation.

4. The upper end of each subsurface drain line shall be capped with a tight fitting cap of the same material as the conduit or other durable material unless connected to a structure.

5. A continuous 10 foot section of corrugated metal, cast iron, or steel pipe without perforations shall be used at the outlet end of the line. No envelope material shall be used around the 10 foot section of pipe. An animal guard shall be installed on the outlet end of the pipe.

6. Earth backfill material shall be placed in the trench in such a manner that displacement of the drain will not occur.

See the following page for the Appendix
for Subsurface Drains

APPENDIX FOR SUBSURFACE DRAINS

DETERMINING SUBSURFACE DRAIN SIZES

Subsurface drains ordinarily are not designed to flow under pressure and the hydraulic gradient is considered to be parallel with the grade line. The flow in the subsurface drain is considered to be open-channel flow. The size of subsurface drain required for a given capacity is dependent on the hydraulic gradient and the roughness coefficient -- "n" value -- of the subsurface drain.

The "n" values for the different materials is as follows:

Description of Pipe or Tubing	"n" value
Plastic, smooth	0.011
Asbestos Cement	0.013
Bituminized Fiber	0.013
Concrete	0.015
Corrugated Plastic	0.015
Corrugated Metal	0.025

The Standard and Specifications for Subsurface Drain states that for a systematic pattern of drains, a drainage coefficient of 1 inch to be removed in 24 hours shall be used. This coefficient is equal to 0.042 cfs. per acre of area to be drained.

Where subsurface drainage is to be by a random system, a minimum inflow rate of 1.5 cfs. per 1,000 feet of line shall be used to determine the required capacity.

If surface water is allowed to enter the system, additional capacity must be provided for and the minimum design velocity shall be 2 feet per second.

The charts are set up for different "n" values. The abscissa of the chart is the hydraulic gradient in feet per foot and the ordinate is the capacity in cubic feet per second. On the chart are plotted the full flow capacity for different pipe diameters and a velocity line for 2 feet per second. The charts are used by going to the next higher pipe diameter line from the point of intersection of the hydraulic gradient and the capacity for the required pipe size since the design is for open-channel flow. Any point to the right or below the 2 feet per second line will have a velocity of less than 2 feet per second.

Examples using the charts are as follows:

Example 1

A random subsurface drain is to be installed. This drain will be 700 feet in length and will be installed at a grade of 0.20%. Bituminized fiber pipe will be used. Determine the size and capacity of the drain.

Solution

From the standard, capacity required = 1.5 cfs per 1000 feet of length.

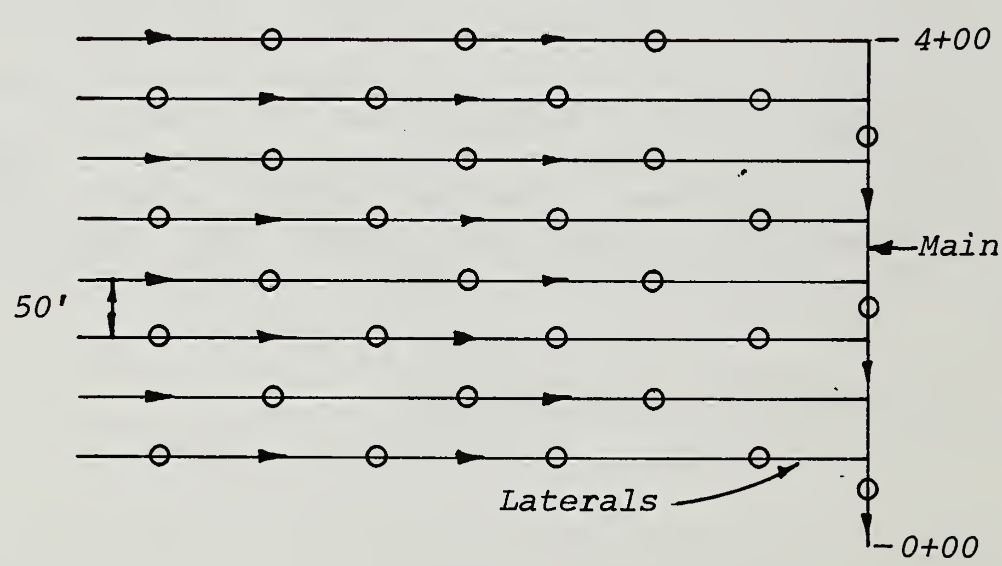
$$\text{Capacity} = \frac{700'}{1000'} \times 1.5 \text{ cfs per } 1000' = 1.05 \text{ cfs}$$

Using Subsurface Drain Capacity Chart for n = 0.013, capacity required = 1.05 cfs, and a gradient of 0.002 ft./ft., the size required is 12" and the actual capacity will be 1.58 cfs.

Example 2

A systematic pattern of subsurface drains is to be installed. There will be eight (8) laterals installed that will be spaced at fifty (50) feet center-to-center and each lateral will be 600 feet in length. The grade of the laterals will be 0.10%. The main will pick up these laterals and will be 400 feet in length. The grade of the main will be 0.10%. Determine the size and capacity of the laterals and the main at the outlet if corrugated plastic tubing is used.

PLAN VIEW



Solution

a. Size and capacity of laterals.

Each lateral will drain for a distance of 25 feet on each side of the line since the spacing is at 50 feet center-to-center. Therefore, each lateral will drain

$$\frac{600' \text{ (length) x } 50' \text{ (width)}}{43{,}560} = 0.69 \text{ acre}$$

Capacity required = 0.69 acre x 0.042 cfs. per acre = 0.029 cfs. Using Subsurface Drain Capacity Chart for n = 0.015, capacity required = 0.029 cfs., and a gradient of 0.001 ft./ft., the size required is 4" and the actual capacity will be 0.052 cfs. (Note: Minimum size allowed is 4".)

b. Size and capacity of the main at the outlet.

For the first 25 feet of the main from the outlet, the main will drain for a distance of 25 feet on each side. For the remaining 375 feet, the main will drain only 25 feet on the one side since the other side is included in the drainage area for the laterals. The main will also drain the laterals. Therefore:

Drainage area from laterals:

= 8 x 0.69 acre = 5.52 acres

Drainage area from main:

$$= \frac{25' \text{ (length) x } 50' \text{ (width)}}{43{,}560} + \frac{375' \text{ (length) x } 25' \text{ (width)}}{43{,}560} = 0.24 \text{ acre}$$

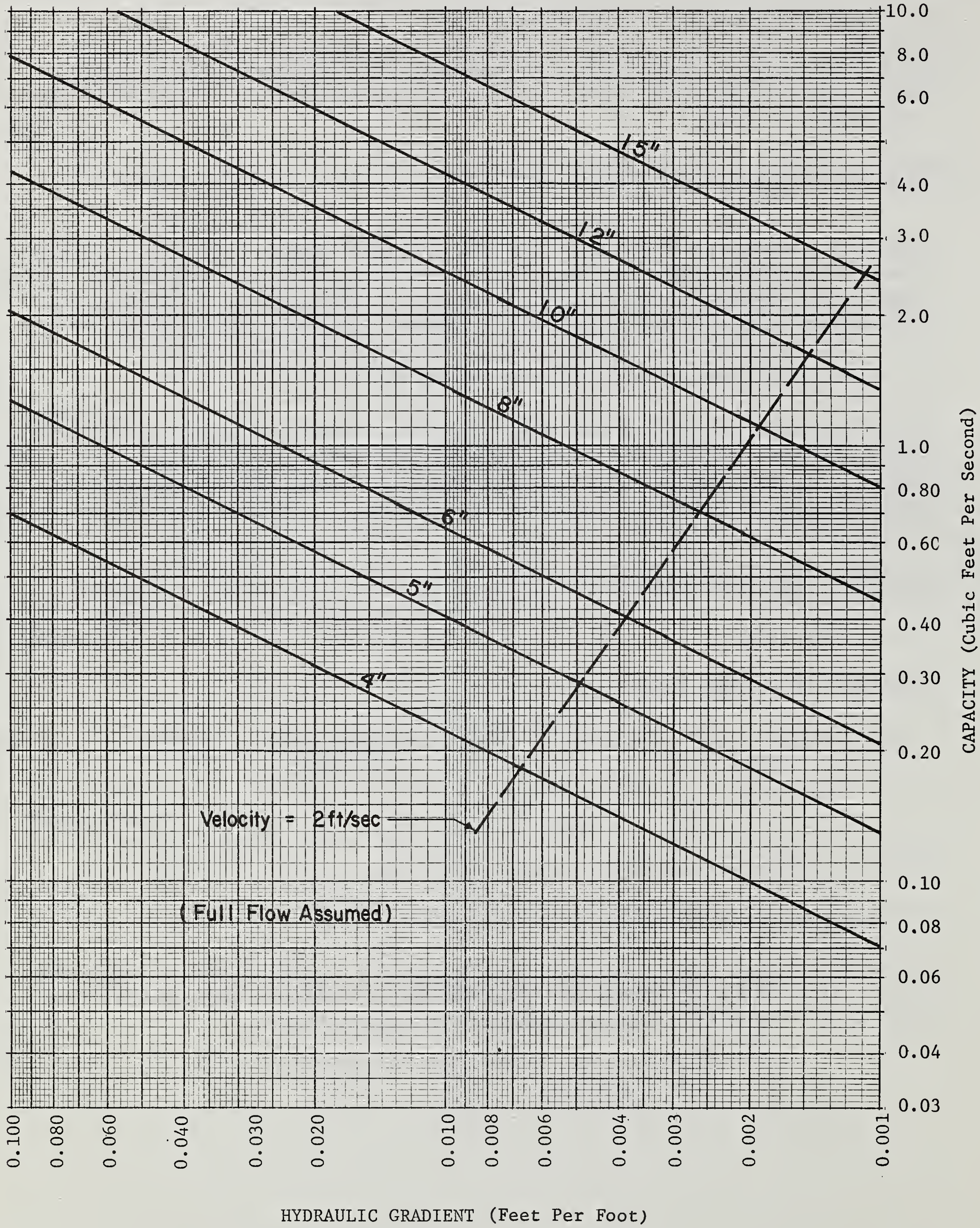
Total = 5.76 acres

Capacity required:

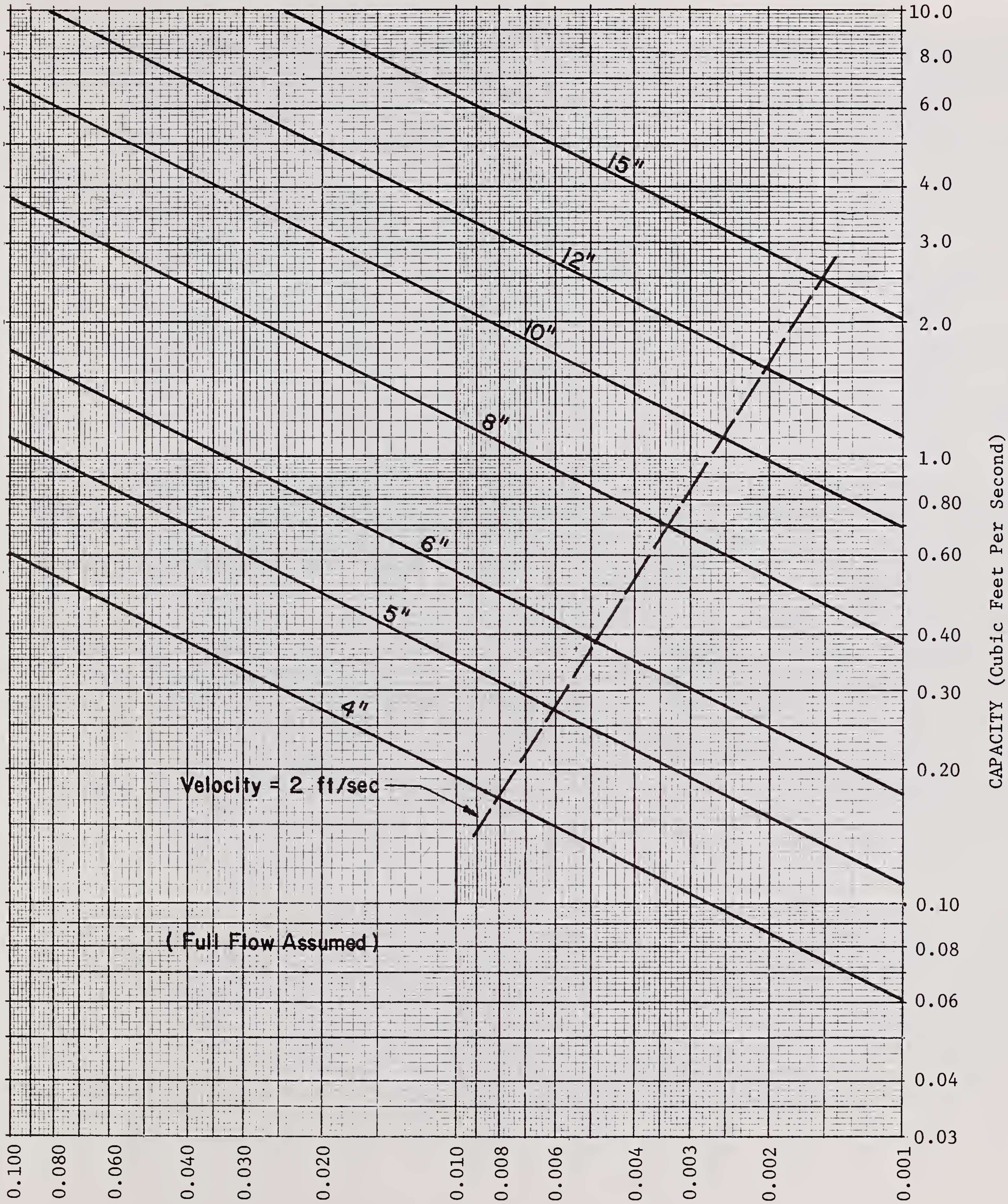
= 5.76 acres x 0.042 cfs/acre = 0.24 cfs.

Using Subsurface Drain Capacity Chart for n = 0.015, capacity required = 0.24 cfs., and a gradient of 0.001 ft./ft., the size required at the outlet is 8" and the actual capacity will be 0.33 cfs.

SUBSURFACE DRAIN CAPACITY CHART - n = 0.011 (14)

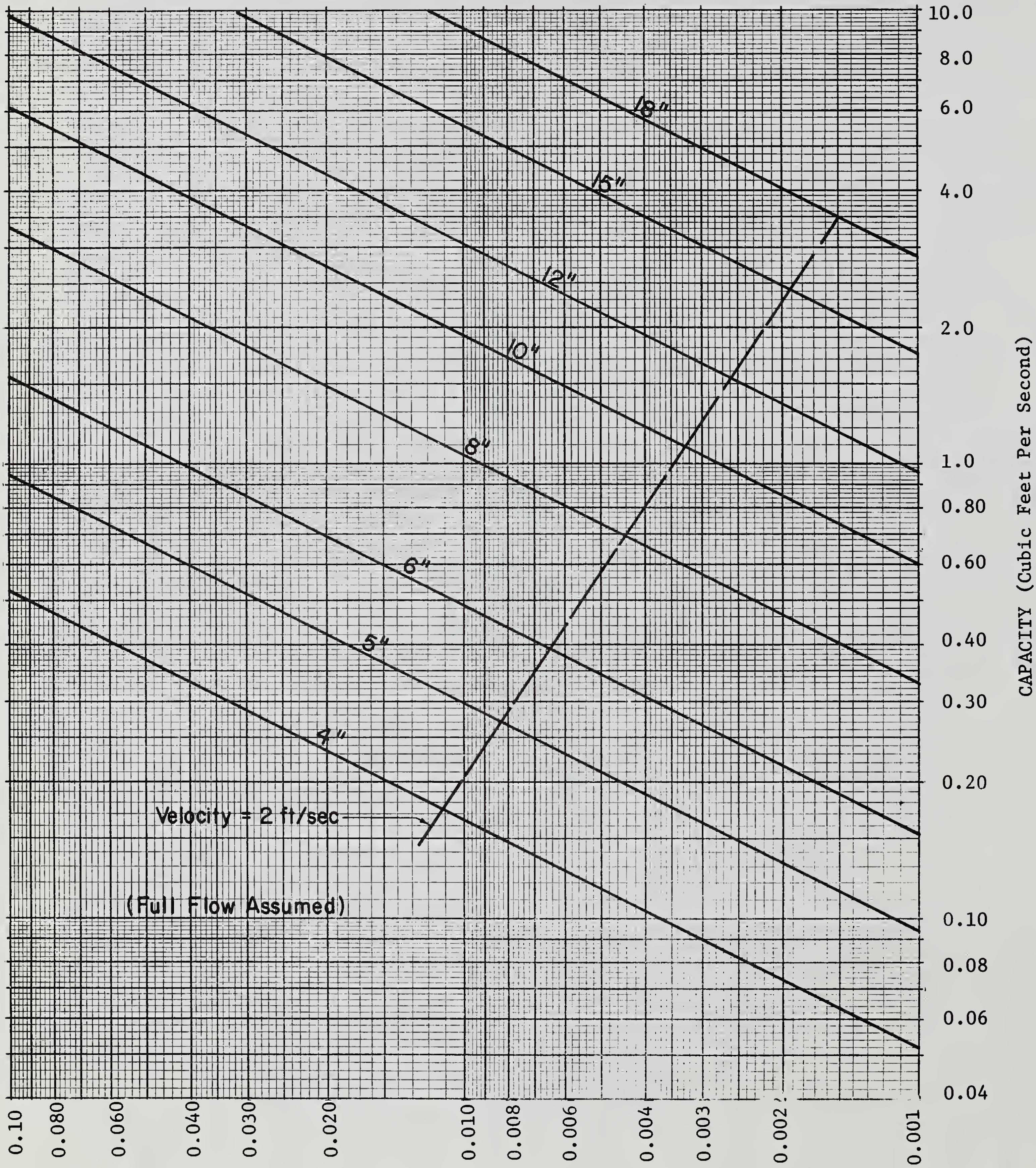


SUBSURFACE DRAIN CAPACITY CHART - n = 0.013



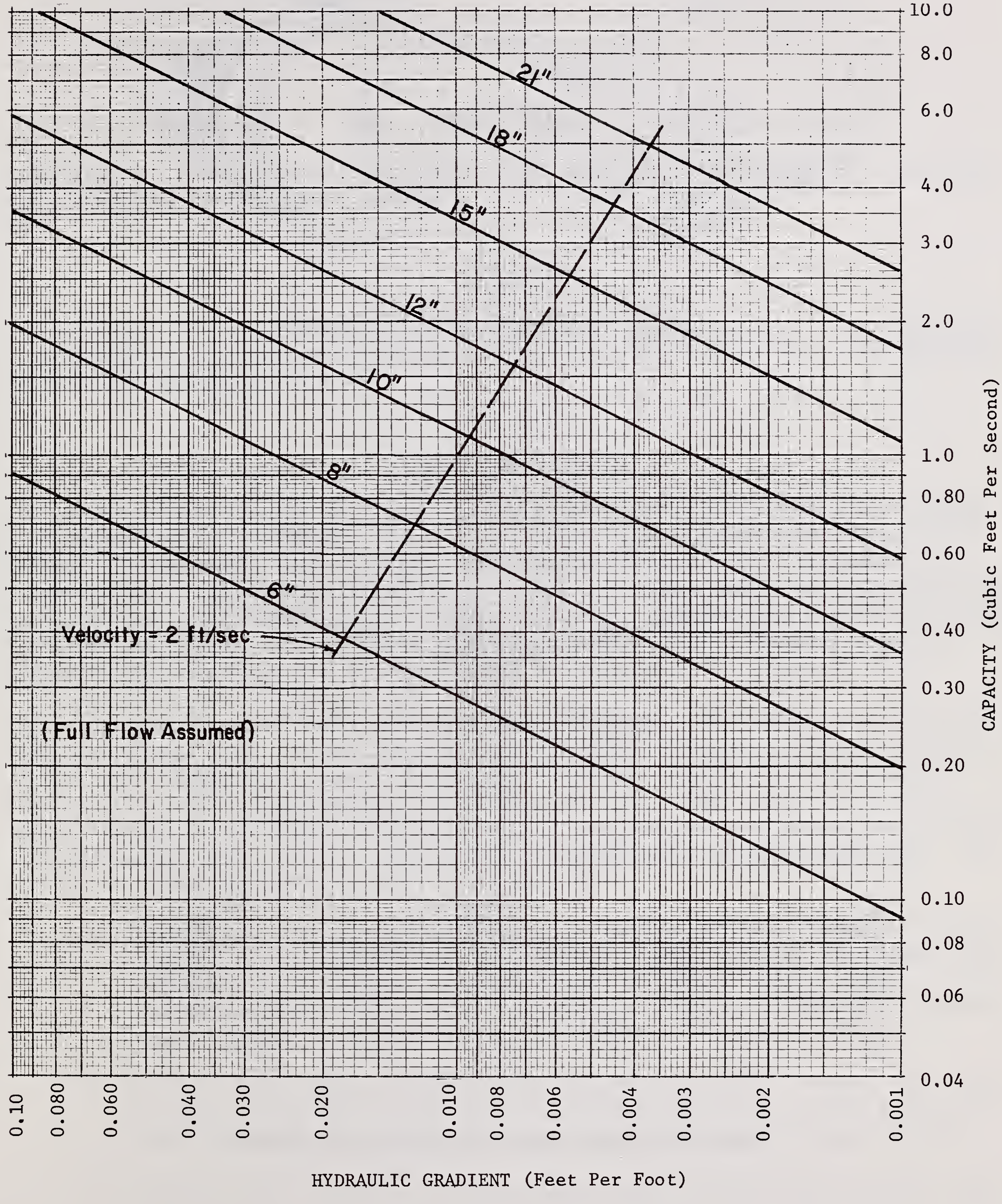
HYDRAULIC GRADIENT (Feet Per Foot)

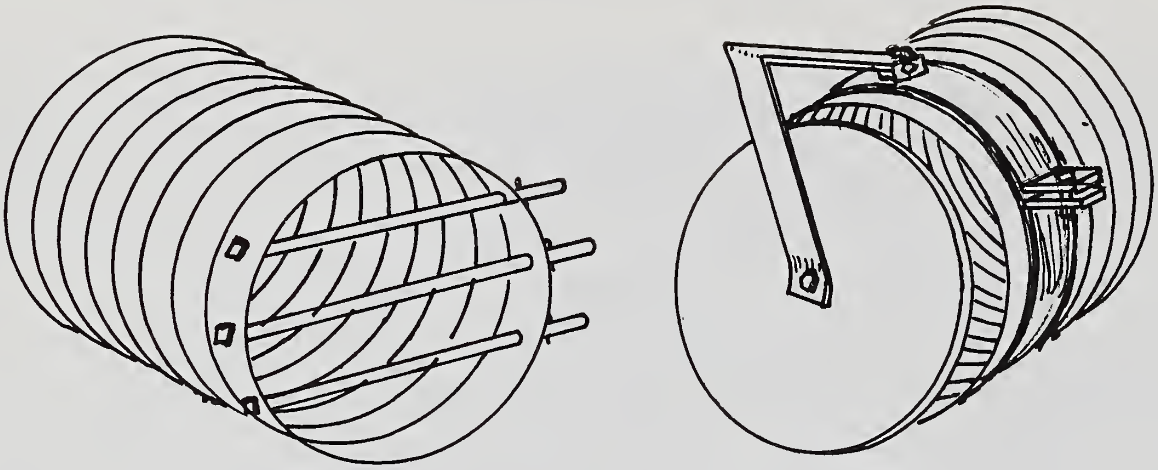
SUBSURFACE DRAIN CAPACITY CHART - n = 0.015



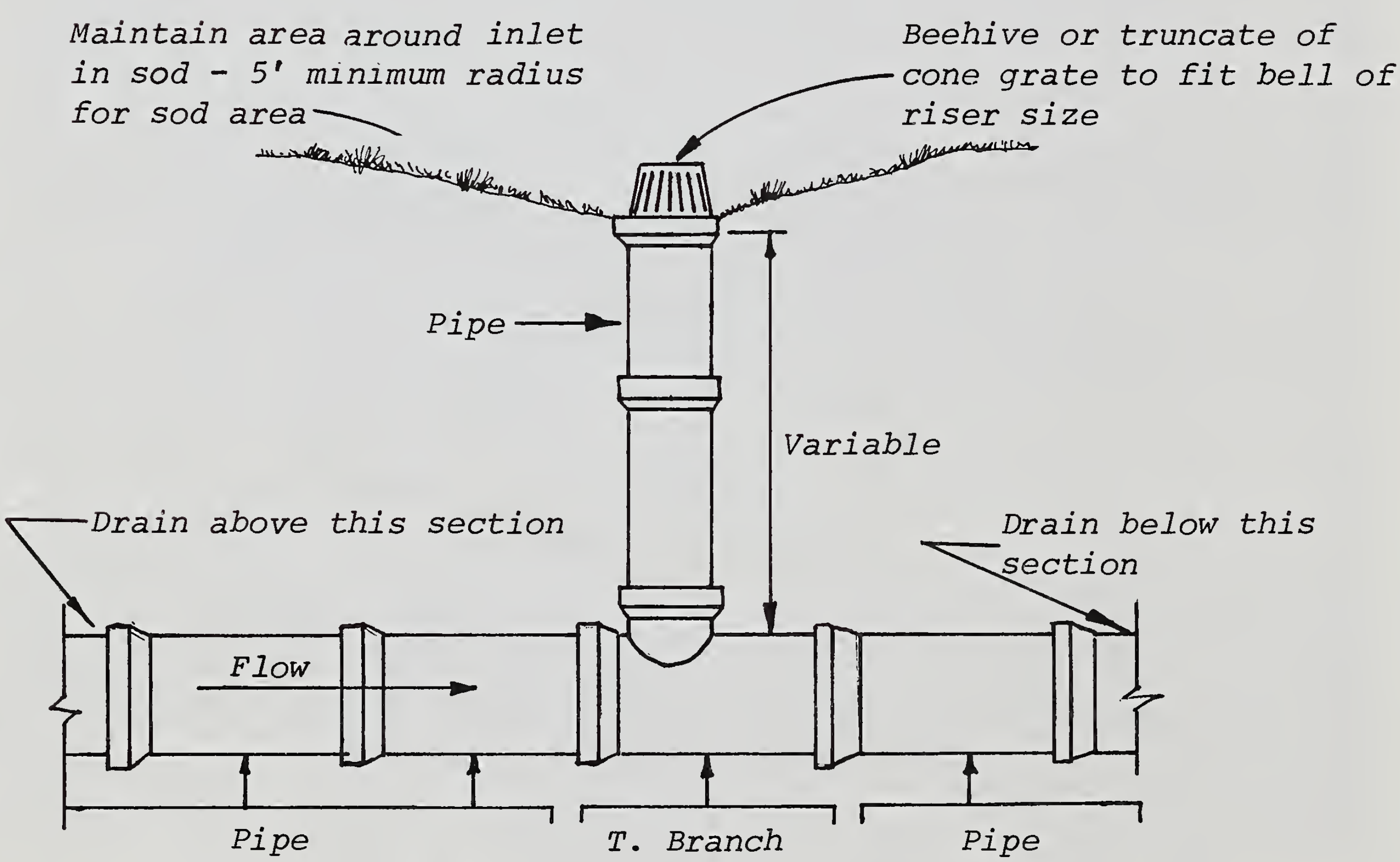
HYDRAULIC GRADIENT (Feet Per Foot)

SUBSURFACE DRAIN CAPACITY CHART - n = 0.025





RODENT PROTECTION FOR OUTLET PIPE



SURFACE WATER INLET TO SUBSURFACE DRAIN

STANDARD AND SPECIFICATIONS

FOR

LAND GRADING

Definition

Reshaping of the existing topography in accordance with a plan as determined by engineering survey and layout.

PURPOSE

The purpose of land grading is to provide for erosion control and vegetative establishment on those areas where the existing topography is to be reshaped by grading according to plan.

DESIGN CRITERIA

The grading plan should be based upon the incorporation of building designs and street layouts that fit and utilize existing topography and desirable natural surroundings to avoid extreme grade modifications. Information submitted will provide sufficient topographic surveys and soil investigations to determine limitations that must be imposed on the grading operation related to slope stability, effect on adjacent properties and drainage patterns, measures for drainage and water removal and vegetative treatment, etc.

The plan must show existing and proposed contours of the area(s) to be graded. The plan shall also include practices for erosion control, slope stabilization, safe disposal of runoff water and drainage, such as waterways, lined ditches, reverse slope benches (include grade and cross-section), grade stabilization structures, retaining walls, and surface and subsurface drains. The plan shall also include scheduling and phasing of these practices. The following shall be incorporated into the plan:

1. Provisions shall be made to safely conduct surface runoff to storm drains, protected outlets or to stable water courses to insure that surface runoff will not damage slopes or other graded areas. (See Standard and Specifications for Grassed Waterway, Diversion, Grade Stabilization Structure).

2. Cut and fill slopes shall not be steeper than 2:1. Where the slope is to be mowed the slope shall be no steeper than 3:1 (4:1 is preferred because of safety factors related to mowing steep slopes).

3. Reverse slope benches or diversions shall be provided whenever the vertical interval (height) of any 2:1 through 5:1 slope exceeds 15

feet. Benches shall be located so as to divide the slope face as equally as possible and shall convey the water to a stable outlet. Soils, seeps, rock outcrops, etc., shall also be taken into consideration when designing benches.

A. Benches shall be wide enough to accomodate the construction equipment in use and provide for ease of maintenance.

B. Benches shall be designed with a reverse slope of 5:1 or flatter to the toe of the upper slope and with a minimum of 1 foot in depth. Bench gradient to the outlet shall be between 1% and 2%.

C. The flow length within a bench shall not exceed 800' unless accompanied by appropriate design and computations. (See Standard and Specifications for Diversion).

4. Surface water shall be diverted from the face of all cut and/or fill slopes by the use of diversions, ditches and swales or conveyed downslope by the use of a designed structure, except where:

A. The length of overland flow (in feet) to the crest of the slope shall not exceed the distance "A" given in the following diagram and example for any combination of side slopes and vertical intervals and;

B. The face of the slope is or shall be stabilized and the face of all graded slopes shall be protected from surface runoff until they are stabilized and;

C. The face of the slope shall not be subjected to any concentrated flows of surface water from natural drainageways, graded swales, downspouts, etc.

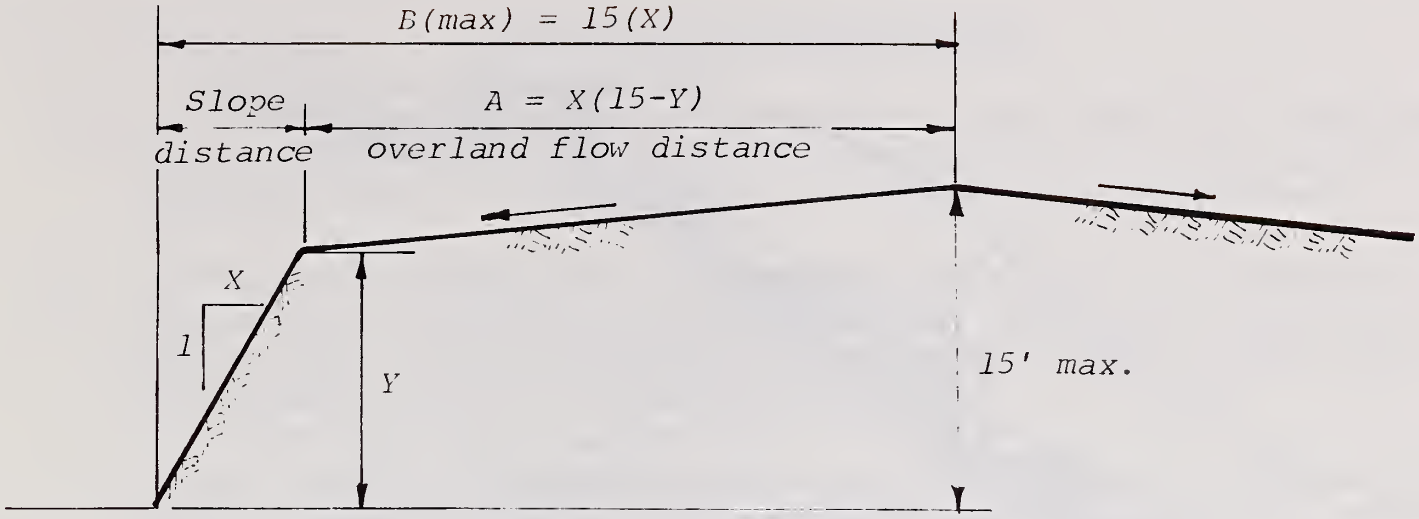
The maximum total horizontal overland-flow-plus-slope distance (B) shall not exceed 15 times the side slope (X) of the cut or fill slope. Maximum allowable overland flow* distance (in feet) to the top of the slope with no diversion of surface water will be determined by use of the formula $A=X(15-Y)$.

A = Maximum overland flow distance in feet to slope crest.

B = Maximum horizontal distance in feet (shall not exceed 15X).

X = Side slope; horizontal distance in feet to 1 foot vertical.

Y = Vertical interval; Height of cut/fill slope in feet measured vertically from bottom elevation of slope to slope crest.



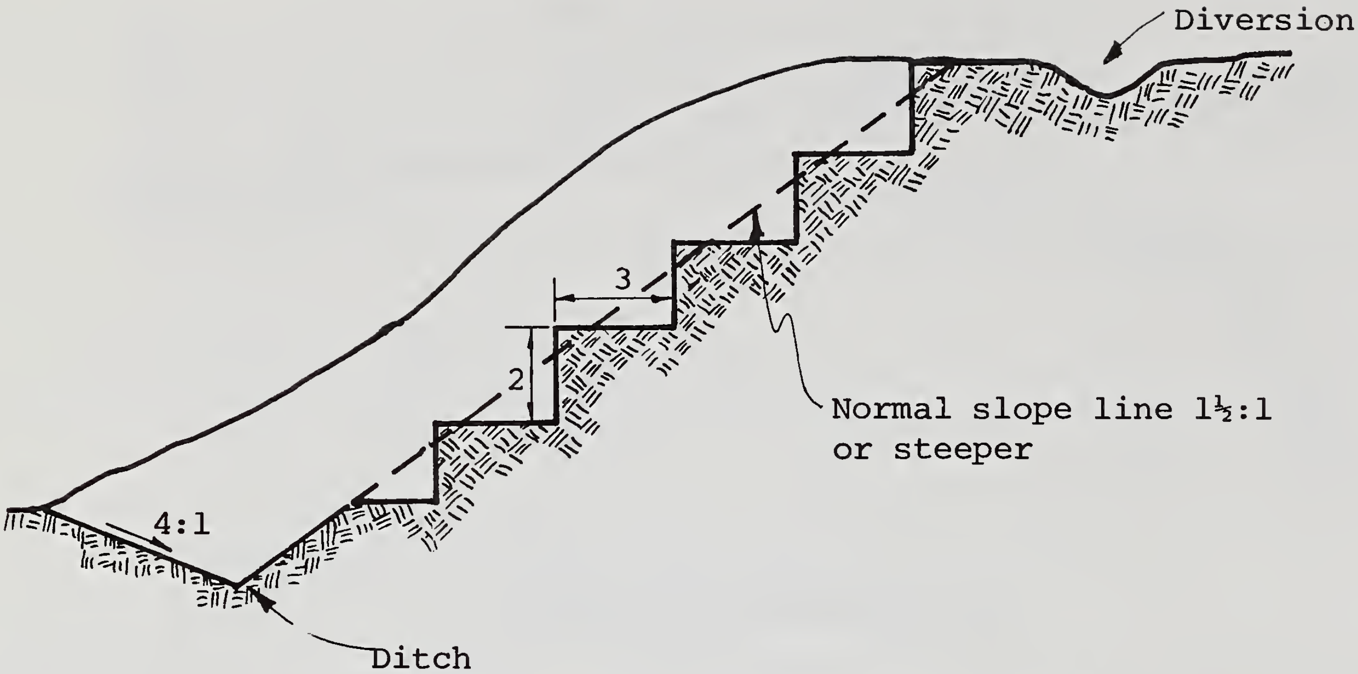
TYPICAL SECTION OF A SLOPE

Example: Determine the maximum allowable overland flow distance, A*, for a 3:1 side slope with a vertical interval of 7 feet.

(X=3) (Y=7)
A = X(15-Y)
A = 3(15-7)
A = 24'

*If maximum allowable overland flow is exceeded surface water shall be diverted from the slope face and carried to a stable outlet, or conveyed downslope with a designed structure.

5. Serrated cut slopes shall be constructed so as to facilitate long-lasting vegetative stabilization. These serrations shall be made in rippable rock with conventional equipment as the excavation is made. Each step or serrate shall be constructed on the contour and will have steps cut at nominal two-foot intervals with nominal three-foot horizontal shelves. These steps will vary depending on the slope ratio of the cut slope. The normal slope line is 1-1/2 :1. These steps will weather and act to hold moisture, lime and fertilizer and seed and to produce a much quicker and longer lived vegetative cover and slope stabilization. Overland flow shall be diverted from the top of all serrated cut slopes and carried to a suitable outlet.



TYPICAL SECTION OF SERRATED CUT SLOPE

6. Subsurface drainage shall be provided where necessary to intercept seepage that would otherwise adversely affect slope stability or create excessively wet site conditions that would hinder or prohibit vegetative establishment (See Standard and Specifications for Subsurface Drain).

7. Slopes shall not be created so close to property lines as to endanger adjoining properties without adequately protecting such properties against erosion, slippage, settlement, subsidence or other related damages.

8. Material for earth fills shall be obtained from designated areas. Except for approved landfills, the fill material shall be free of brush, rubbish, rocks, logs, stumps, building debris, and other objectionable material that would interfere with or prevent construction of satisfactory fills. It should be free of stones over two (2) inches in diameter where compacted by hand or mechanical tampers or over six (6) inches in diameter where compacted by rollers or other equipment. Frozen material shall not be placed in the fill nor shall the fill material be placed on a frozen foundation.

9. Stockpiles, borrow areas and spoil areas shall be shown on the plans and shall be subject to the provisions of this Standard and Specifications.

10. All disturbed areas shall be stabilized structurally or vegetatively in compliance with the "Standard and Specifications for Soil Erosion and Sediment Control in Developing Areas".

See Standard Drawing LG-1.

CONSTRUCTION SPECIFICATIONS

1. All graded or disturbed areas including slopes shall be protected during clearing and construction in accordance with the approved sediment control plan until they are permanently stabilized.

2. All sediment control practices and measures shall be constructed, applied and maintained in accordance with the approved sediment control plan and the "Standards and Specifications for Soil Erosion and Sediment Control in Developing Areas"

3. Topsoil required for the establishment of vegetation shall be stock-piled in amount necessary to complete finished grading of all exposed areas.

4. Areas to be filled shall be cleared, grubbed and stripped of topsoil to remove trees, vegetation, roots or other objectionable material.

5. Areas which are to be topsoiled shall be scarified to a minimum depth of three inches prior to placement of topsoil.

6. All fills shall be compacted as required to reduce erosion, slippage, settlement, subsidence or other related problems. Fill intended to support buildings, structures and conduits, etc., shall be compacted in accordance with local requirements or codes.

7. All fill shall be placed and compacted in layers not to exceed 8 inches in thickness.

8. Except for approved landfills, fill material shall be free of brush, rubbish, rocks, logs, stumps, building debris and other objectionable materials that would interfere with or prevent construction of satisfactory fills.

9. Frozen material or soft, mucky or highly compressible materials shall not be incorporated into fills.

10. Fill shall not be placed on a frozen foundation.

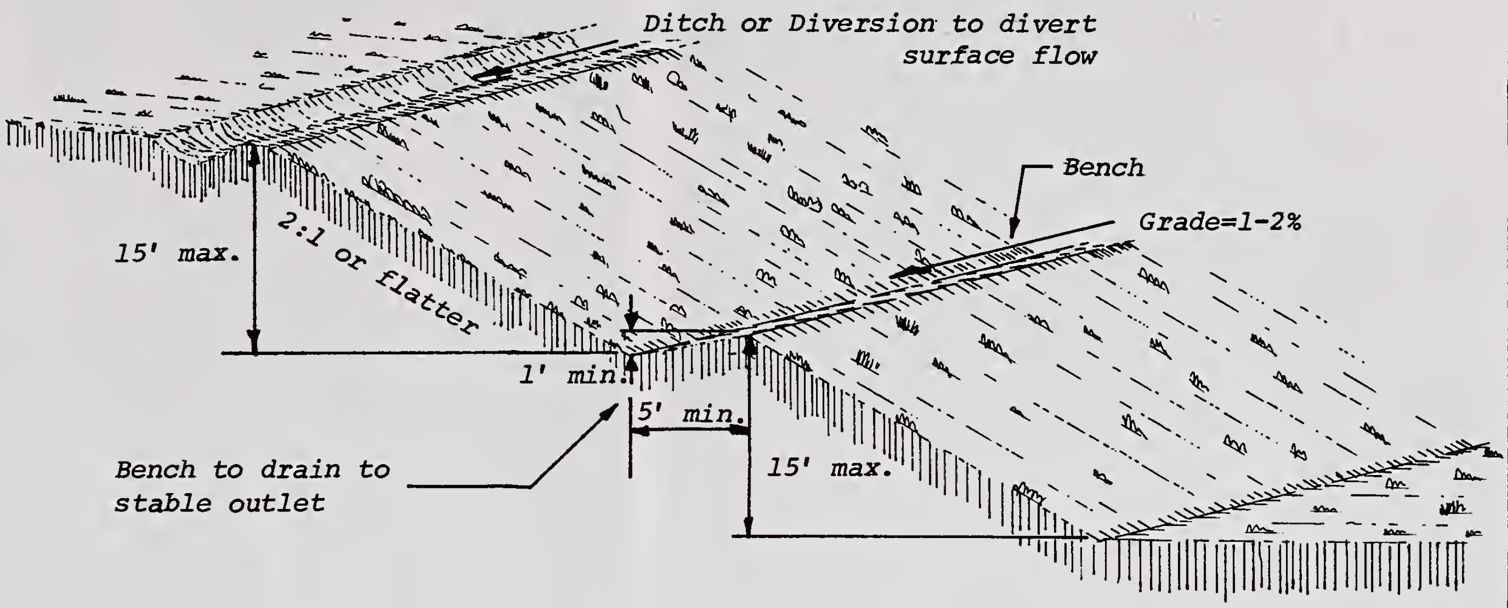
11. All benches shall be kept free of sediment during all phases of development.

12. Seeps or springs encountered during construction shall be handled in accordance with the Standard and Specifications for Subsurface Drain or other approved methods.

13. All graded areas shall be permanently stabilized immediately following finished grading.

14. Stockpiles, borrow areas, and spoil areas shall be shown on the plans and shall be subject to the provisions of this Standard and Specifications.

LANDGRADING



SLOPE DETAIL (WITH BENCH)

Construction Specifications

1. All graded or disturbed areas including slopes shall be protected during clearing and construction in accordance with the approved sediment control plan until they are permanently stabilized.
2. All sediment control practices and measures shall be constructed, applied and maintained in accordance with the approved sediment control plan and the "Standards and Specifications for Soil Erosion and Sediment Control in Developing Areas".
3. Topsoil required for the establishment of vegetation shall be stockpiled in amount necessary to complete finished grading of all exposed areas.
4. Areas to be filled shall be cleared, grubbed and stripped of topsoil to remove trees, vegetation, roots or other objectionable material.
5. Areas which are to be topsoiled shall be scarified to a minimum depth of three inches prior to placement of topsoil.
6. All fills shall be compacted as required to reduce erosion, slippage, settlement, subsidence or other related problems. Fill intended to support buildings, structures and conduits, etc., shall be compacted in accordance with local requirements or codes.
7. All fill to be placed and compacted in layers not to exceed 8 inches in thickness.
8. Except for approved landfills, fill material shall be free of brush, rubbish, rocks, logs, stumps, building debris and other objectionable materials that would interfere with or prevent construction of satisfactory fills.
9. Frozen materials or soft, mucky or highly compressible materials shall not be incorporated into fills.
10. Fill shall not be placed on a frozen foundation.
11. All benches shall be kept free of sediment during all phases of development.
12. Seeps or springs encountered during construction shall be handled in accordance with the Standard and Specifications for Subsurface Drain or other approved method.
13. All graded areas shall be permanently stabilized immediately following finished grading.
14. Stockpiles, borrow areas and spoil areas shall be shown on the plans and shall be subject to the provisions of this Standard and Specifications.

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE College Park, Md.	LANDGRADING	Standard Drawing LG-1

EROSIVE SPLASH OF RAINDROP
STRIKING BARE SOIL

VEGETATIVE COVER ARRESTS THE DESTRUCTIVE ENERGY OF RAINDROPS

SECTION III

STANDARDS AND SPECIFICATIONS

FOR

VEGETATIVE PRACTICES

STANDARD AND SPECIFICATIONS

FOR

CRITICAL AREA STABILIZATION
(With Temporary Seeding)

Definition

Planting short-term vegetation on critical areas.

Purpose

To stabilize the soil; to reduce damages from sediment and runoff to downstream areas; improve wildlife habitat; enhance natural beauty.

Conditions Where Practice Applies

On graded or cleared areas which are subject to erosion for a year or less; permanent structures are to be installed or extensive grading of the area will be done prior to establishment of permanent vegetation.

SPECIFICATIONS

I. Site Preparation

A. Prior to seeding, install needed erosion control practices such as diversions, grade stabilization structures, berms, dikes, level spreaders, grassed waterways, and sediment basins.

B. Final grading and shaping has usually not been completed for temporary seedings.

II. Soil Amendments

For temporary seedings, fertilizer shall be applied at the rate of 600 lbs/ac. or 15 lbs/1000 sq. ft., using 10-20-10 or equivalent. Soils which are known to be highly acid should be limed.

III. Seedbed Preparation

When the area to be seeded has been recently loosened to the extent that an adequate seedbed exists, no additional treatment is required.

However, when the area to be seeded is packed, crusted, and hard, the top layer of soil shall be loosened by discing, raking or other acceptable means before seeding.

IV. Seeding

A. Select a mixture from Table 50-1.

B. Apply seed uniformly with a cyclone seeder, drill, cultipacker seeder or hydroseeder (slurry includes seed and fertilizer).

V. Mulching

When seedings are made on critical sites or adverse soil conditions, other than optimum seeding dates, mulch material will be applied immediately after seeding. Seedings made during optimum seeding dates and with favorable soils and site conditions will not need to be mulched.

A. Materials and Amounts

1. Straw - Material shall be unrotted small grain straw applied at the rate of 1-1/2 to 2 tons per acre, or 70 to 90 pounds per 1,000 sq. ft. Mulch materials shall be relatively free of all kinds of weeds and shall be free of prohibited noxious weeds which are: Canada thistle, Johnsongrass and quackgrass.

   Spread uniformly by hand or mechanically. For uniform distribution of hand spread mulch, divide area into approximately 1,000 sq. ft. section and place 70-90 lbs. of mulch in each section..

2. Wood-fiber or paper-fiber mulch at the rate of 1,500 pounds per acre or 35 pounds per 1,000 sq. ft. may be applied by hydroseeding. Use is limited to <3% and <150' length of slope and during optimum seeding periods in spring and fall.

3. Mulch nettings such as jute or excelsior blanket may be used. Staple to surface in waterways and on steep slopes. Lighter materials of paper, plastic and cotton mulch nettings may be used where erosion hazard is not severe. If area is to be mowed, do not use metal staples.

4. Wood chips at the rate of approximately 6 tons per acre or 275 lbs. per 1,000 sq. ft. may be used when available and when feasible to use.

B. Mulch anchoring shall be accomplished immediately after mulch placement to minimize loss by wind or water. This may be done by one of the following methods, depending upon size of area, erosion hazard, and cost. On sloping land, practice No. 3 below, should be done on the contour wherever possible, except "tracking" should be done up and down the slope with 1-1/2 inch cleat marks running across the slope.

1. Peg and Twine - Drive 8 to 10-inch wooden pegs to within 2 to 3 inches of the soil surface every 4 feet in all directions. Stakes may be driven before or after applying mulch. Secure mulch to soil surface by stretching twine between pegs in a criss-cross within a square pattern. Secure twine around each peg with two or more round turns.

2. Mulch Nettings - Staple lightweight biodegradable paper, plastic or cotton nettings over the mulch according to manufacturer's recommendations. Netting is usually available in rolls 4 feet wide and up to 300 feet long.

3. Mulch Anchoring Tool (not a disc) - A tractor drawn implement designed to punch and anchor mulch into the surface 2 inches of soil. This practice affords maximum erosion control but is limited to flatter slopes where equipment can operate safely. Tracking - primarily used on steeper than 3:1 cut and fill slopes to cut the mulch into the soil with cleated bulldozer tracks.

4. Liquid Mulch Binders
   Applications of liquid binders should be heavier at edges where wind catches mulch, in valleys, and at crests of banks. Remainder of area should be uniform in appearance. Caution should be used with asphalt in residential and similar areas.

   a. Cutback asphalt - rapid curing (RC-70, RC-250, and RC-800) or medium curing (MC-250 or MC-800). Apply 5 gallons per 1,000 sq. ft. or 218 gallons per acre on flat areas, and on slopes less than 8 feet high. On slopes 8 feet or more high, use 8 gallons per 1,000 sq. ft. or 348 gallons per acre.

   b. Emulsified asphalt - (SS-1, CSS-1, CMS-2, MS-2, RS-1, RS-2, CRS-1, and CRS-2). Apply 5 gallons per 1,000 sq. ft. or 218 gallons per acre on flat areas and on slopes less than 8 feet high. On slopes 8 ft. or more high, use 8 gallons per 1,000 sq. ft. or 348 gallons per acre.

      All asphalt designations are from the Asphalt Institute Specifications.

   c. Synthetic binders - Synthetic binders such as Curasol, DCA-70, Petroset and Terra Tack may be used at rates recommended by the manufacturer to anchor mulch material.

      Note: All names given above are registered trade names. This does not constitute a recommendation of these products to the exclusion of other products.

TABLE 50-1

Temporary Seedings by Rates, Depths and Dates

Species 3/	Seeding Rate		Planting Depth 2/	Seeding Dates 6/								
				COASTAL PLAIN			PIEDMONT			MOUNTAINS		
	Per Acre	Lbs/1000 sq. ft.	(Inches)	2/1-4/30	5/1-8/14	8/15-11/30	3/1-4/30	5/1 8/14	8/15-11/15	3/15-5/31	6/1-7/31	8/1-10/31
Choose one:				5/			5/					
Barley	2-1/2 bu.	2.8	1-2	x	-	By 10/15	x	-	By 10/15	x	-	By 10/1
Oats	3 bu.	2.2	1-2	x	-	-	x	-	-	x	-	-
Rye	2-1/2 bu.	3.2	1-2	x	-	x	x	-	x	x	-	x
Italian or perennial ryegrass 1/	40 lbs.	.92	1/4-1/2	5/ x	-	By 11/1	5/ x	-	By 11/1	x	-	By 8/15
Millet	40 lbs.	.92	1-2	-	x	-	-	x	-	-	x	-
Weeping, Boer, or Lehmann's lovegrass	3 lbs.	.07	1/4-1/2	-	x	-	-	x	-	-	x	-
Sudangrass 4/	40 lbs.	.92	1-2	-	x	-	-	x	-	-	x	-

1/ Use only on areas where seed stalks and volunteer growth are acceptable.

2/ Applicable on slopes 3:1 or less.

3/ Use varieties currently recommended for Maryland. Use certified seed when available.

4/ Use common sudangrass varieties only. Do not use hybrids.

5/ Twenty pounds per acre of annual lespedeza may be added to 1/2 the seeding rate of any species used for spring seedings.

6/ Between fall and spring seeding dates, use mulching only or sodding practices

x Applicable during entire period.

- Not applicable in period.

References

1. USDA, Soil Conservation Service Field Office Technical Guides.

2. Maryland State Highway Administration Specifications.

Note: Maryland Water Resources Administration has developed an Audiovisual Training Program, "Temporary Soil Stabilization", which relates to this subject.

STANDARD AND SPECIFICATIONS

FOR

CRITICAL AREA STABILIZATION
(With Permanent Seedings)

Definition

Planting vegetation such as grasses and legumes on critical areas.

Purpose

To stabilize the soil; to reduce damages from sediment and runoff to downstream areas; improve wildlife habitat; enhance natural beauty.

Conditions Where Practices Apply

Graded or cleared areas subject to erosion and where a permanent, long-lived vegetative cover is needed.

SPECIFICATIONS

Vegetation cannot be expected to provide an erosion control cover and prevent soil slippage on a soil that is not stable due to its texture, structure, water movement or excessive slope.

Minimum soil conditions needed for the establishment and maintenance of a long-lived vegetative cover:

A. Enough fine-grained materials (over 30 percent silt plus clay) to provide the capacity to hold at least a moderate amount of available moisture. Noticeable exception would be planting lovegrass and sericea lespedeza which can be planted on a sandier soil.

B. Sufficient pore space to permit adequate root penetration.

C. The soil shall be free from any material harmful to plant growth.

D. If these minimum conditions cannot be met, see specification, Topsoiling (57.01).

I. Site Preparation

A. Install needed erosion control practices such as interceptor dikes, berms and spreaders, contour ripping, erosion stops, channel liners and sediment basins.

B. Grade as needed and feasible to permit the use of conventional equipment for seedbed preparation, seeding, mulch application, anchoring and maintenance.

II. Seedbed Preparation

Flat areas and slopes up to 3 to 1 grade shall be loose and friable to a depth of at least 3 inches. The top layer of soil shall be loosened by raking, discing or other acceptable means before seeding.

Slopes steeper than 3 to 1 shall have the top 1-3 inches of soil loose and friable before seeding.

III. Soil Amendments

Lime and fertilize according to soil tests. Lime and fertilizer needs can be determined by a soil testing laboratory, such as the University of Maryland's Soil Testing Laboratory.

In lieu of soil test results, apply 2 tons dolomitic limestone and 600 pounds 0-20-20, or equivalent per acre before seeding. Harrow or disc lime and 0-20-20, or equivalent fertilizer uniformly into the soil to minimum depth of 3 inches on slopes flatter than 3 to 1. On slopes of greater than 3 to 1 grade, the lime and fertilizer shall be worked in as directed by the contracting officer. On sloping land, the final harrowing or discing operation should be on the contour wherever feasible. No attempt should be made to drag any disced area to make the soil surface very smooth after discing. At time of seeding, apply 400 pounds 38-0-0 ureaform fertilizer and 500 pounds 10-20-20, or equivalent fertilizer per acre. For mixtures containing perennial legumes, the 500 pounds of 10-20-20 may be omitted.

IV. Seeding

A. Select a mixture from table 51-1.

B. Apply seed uniformly with a cyclone seeder, drill, cultipacker seeder or hydroseeder (slurry includes seed and fertilizer) on a firm, moist seedbed. Maximum seeding depth should be 1/4 inch on clayey soils and 1/2 inch on sandy soils, when using other than hydroseeder method of application.

V. Mulching

A. Materials and Amounts

1. Straw - Straw shall be unrotted small grain straw applied at the rate of 1-1/2 to 2 tons per acre, or 70 to 90 pounds per 1,000 sq. ft. Mulch materials shall be relatively free of all kinds of weeds and shall be free of prohibited noxious weeds which are: Canada thistle, Johnsongrass and quackgrass.

   Spread uniformly by hand or mechanically. For uniform distribution of hand spread mulch, divide area into approximately 1,000 sq. ft. section and place 70-90 lbs. of mulch in each section.

2. Wood-fiber or paper-fiber mulch at the rate of 1,500 pounds per acre or 35 pounds per 1,000 sq. ft. may be applied by hydroseeding. Use is limited to < 3% and < 150' length of slope and during optimum seeding periods in spring and fall.

3. Mulch nettings such as jute or excelsior blanket may be used. Staple to surface in waterways and on steep slopes. Lighter materials of paper, plastic and cotton mulch nettings may be used where erosion hazard is not severe. If area is to be mowed, do not use metal staples.

4. Wood chips at the rate of approximately 6 tons per acre or 275 lbs. per 1,000 sq. ft. may be used when available and when feasible to use. Particularly well-suited for utility and road rights-of-way.

B. Mulch anchoring shall be accomplished immediately after mulch placement to minimize loss by wind or water. This may be done by one of the following methods, depending upon size of area, erosion hazard, and cost. On sloping land, practice No. 3 below, should be done on the contour wherever possible. Applies to all straw and to wood chips or more critical sites, except "tracking" should be done up and down the slope with 1-1/2 inch cleat marks running across the slope.

1. Peg and Twine - Drive 8 to 10-inch wooden pegs to within 2 to 3 inches of the soil surface every 4 feet in all directions. Stakes may be driven before or after applying mulch. Secure mulch to soil surface by stretching twine between pegs in a criss-cross within a square pattern. Secure twine around each peg with two or more round turns.

2. Mulch Nettings - Staple lightweight biodegradable paper, plastic or cotton nettings over the mulch according to manufacturer's recommendations. Netting is usually available in rolls 4 feet wide and up to 300 feet long.

3. Mulch Anchoring Tool - A tractor drawn implement designed to punch and anchor mulch into the surface 2 inches of soil. This practice affords maximum erosion control but is limited to flatter slopes where equipment can operate safely. Tracking - primarily used on > 3:1 cut and fill slopes to cut the mulch into the soil with bulldozer cleats.

4. Liquid Mulch Binders

   Applications of liquid binders should be heavier at edges where wind catches mulch, in valleys, and at crests of banks. Remainder of area should be uniform in appearance. Caution should be used with asphalt in residential and similar areas.

   a. Cutback asphalt - rapid curing (RC-70, RC-250, and RC-800) or medium curing (MC-250 or MC-800). Apply 5 gallons per 1,000 sq. ft. or 200 gallons per acre on flat areas, and on slopes less than 8 feet high. On slopes 8 feet or more high, use 8 gallons per 1,000 sq. ft. or 348 gallons per acre.

   b. Emulsified asphalt - (SS-1, CSS-1, CMS-2, MS-2, RS-1, RS-2, CRS-1, and CRS-2). Apply 5 gallons per 1,000 sq. ft. or 200 gallons per acre on flat areas and on slopes less than 8 feet high. On slopes 8 feet or more high, use 8 gallons per 1,000 sq. ft. or 348 gallons per acre.

      All asphalt designations are from the Asphalt Institute Specifications.

   c. Synthetic binders - Synthetic binders such as Curasol, DCA-70, Petroset and Terra Tack may be used at rates recommended by the manufacturer to anchor mulch material.

      Note: All names given above are registered trade names. This does not constitute a recommendation of these products to the exclusion of other products.

VI. Irrigation

If soil moisture is deficient, supply new seedings with adequate water for plant growth until they are firmly established, if feasible. This is especially true when seedings are made late in the planting season, in abnormally dry or hot seasons, or on adverse sites.

VII. Maintenance

Maintenance is a vital factor in maintaining an adequate vegetative erosion control cover. See Table 51-2.

A. Irrigation - If soil moisture becomes deficient, irrigate to prevent loss of stand of protective vegetation, if feasible.

B. Repairs - Inspect all seed areas for failures and make necessary repairs, replacements, and reseedings within the planting season, if possible.

1. If stand is inadequate for erosion control, overseed and fertilize using half of the rates originally applied.

2. If stand is over 60% damaged, reestablish following original lime, fertilizer, seedbed preparation and seeding recommendations.

References

1. Lawn Care in Maryland, Bulletin 171; Cooperative Extension Service, University of Maryland, College Park, Maryland.

2. Maryland State Highway Administration Specifications for Materials.

3. USDA - Soil Conservation Service Field Office Technical Guides.

Note: Maryland Department of Water Resources has developed an audiovisual training program, "Plant Materials and Vegetative Soil Stabilization", which relates to this practice.

TABLE 51-1
Permanent Seedings and Seeding Dates,

Mix. No.	SEEDING MIXTURES (Use Certified Seed if available)	SEEDING RATE Lbs/ Acre	Lbs/1000 Sq. Ft.	OPTIMUM SEEDING DATES (e) COASTAL PLAIN 2/1-4/30	5/1-8/14	8/15-10/31	PIEDMONT 3/1-4/30	5/1-3/31	8/1-10/15	MOUNTAINS 3/5-5/31	6/1-7/31	8/1-9/30
1.	'Kentucky 31' Tall Fescue *	60	1.38	x	-	x	x	-	x	x	-	x
2.	'Kentucky 31' Tall Fescue * Weeping lovegrass (a)	60 2	1.38 .05	-	x	-	-	x	-	-	x	-
3.	'Kentucky 31' Tall Fescue * 'Korean' lespedeza (b) inoculated	50 15	1.15 .34	x	-	-	x	-	-	-	-	-
4.	'Kentucky 31' Tall Fescue * Sericea lespedeza (b) inoculated	40 20	.92 .46	x	-	x	x	-	x	x	-	x
5.	'Kentucky 31' Tall Fescue * Birdsfoot trefoil, inoculated	40 10	.92 .23	-	-	-	-	-	-	x 2000' elev. & above	-	
6.	Crownvetch, inoculated Redtop	15 3	.34 .07	x	-	-	x	-		x	-	
7.	Crownvetch, inoculated 'Kentucky 31' Tall Fescue *	15 40	.46 .92	x	-		x	-		x	-	
8.	Droughty Areas 'Kentucky 31' Tall Fescue * Redtop	30 5	.69 .11	x	-	x	x	-	x	x	-	x
9.	Weeping lovegrass Sericea lespedeza (b) inoculated	2 20	.05 .46	x	x	-	x	x	-	x	x	-
10.	Poorly Drained Areas 'Kentucky 31' Tall Fescue *	30	.69	x	-	x	x	-	x	x	-	x
11.	Reed canarygrass (c)	10	.23									
12.	Shaded Areas 'Kentucky 31' Tall Fescue *	60	1.38	x	-	x	x	-	x	x	-	x
13.	Red Fescue 'Jamestown' or 'Penn-lawn'	40	.92	x	-	x	x	-	x	x	-	x
14.	Lawns & High Maintenance Areas 'Merion' Kentucky Bluegrass * Common Kentucky Bluegrass* (d) Red Fescue, 'Pennlawn' or 'Jamestown'	40 40 20	.92 .92 .46	x	-	x	x	-	x	x	-	x
15.	'Kentucky 31' Tall Fescue * (g)	220-260	5-6	x	x (f)	x	x	x (f)	x	x	x (f)	x

* Use certified seed only

Footnotes - Table 51-1

Permanent Seedings and Seeding Dates (continued)

(a) Use Weeping lovegrass to provide a stand of grass for erosion control during summer.

(b) Use hulless seed.

(c) Preferable to seed in fall with seed from current year's crop.

(d) 'South Dakota' certified or 'Kenblue' Kentucky bluegrass are the only acceptable varieties for use in these areas.

(e) Mixtures 1,3,4,5,6,7,8,10,11,12,13 and 14 may be seeded during winter months in an emergency if 2 tons per acre of a well-anchored mulch is used.

(f) Can be seeded during this period if irrigation water is used. Use 2 tons per acre of mulch.

(g) Can use 10 percent Kentucky bluegrass.

Notes: 1. Scientific names of these plants are in appendix B-1.01 and B-1.02.

2. Approved State Highway Administration Mixtures may be used.

TABLE 51-2
Maintenance Fertilization for Permanent Seedings
Use Soil Test Recommendations or Rates Shown Below

Mixture No.	Seeding Mixture	Formulation	Lbs. Per Acre	Lbs. Per 1000 Sq. Ft.	Time	Mowing
1,2,3,7,8, 10,11	Tall fescue makes up 70% or more of cover.	10-10-10 or 38-0-0+ 0-20-20	500 400 250	11.5 9.2 5.8	Fall Yearly, or as needed Fall. Yearly, or as needed	*Not closer than 3" if occasional mowing is desired.
4,5,6,7,9,	Crownvetch Sericea lespedeza Birdsfoot trefoil	0-20-20	400	9.2	Spring. Year following establishment and every 4-5 yrs. thereafter	Do not mow crownvetch.
4,5	Fairly uniform stand of tall fescue and sericea lespedeza, or birdsfoot trefoil.	5-10-10	500	11.5	Fall. Year following establishment and every 4-5 yrs. thereafter	Not required. Not closer than 4" if occasional mowing is desired, & then in fall after sericea seed has matured.
9	Weeping lovegrass & sericea lespedeza. Fairly uniform plant distribution	5-10-10	500	11.5	Spring Year following establishment & every 3-4 yrs. thereafter	Not required. Not closer than 4" if occasional mowing is desired, & then in fall after sericea seed has matured.
12,13,14	Red fescue; Kentucky bluegrass-red fescue mixture; 'Ky-31' tall fescue	20-10-10 20-10-10 20-10-10 20-10-10	250 250 250 100	5.8 5.8 5.8 2.3	September 30 days later. December May 20-June 30, if needed	Mow no closer than 2" for red fescue & Ky. bluegrass; & no closer than 3" for tall fescue

Note: Fertilization schedule applies alike to mixtures 12, 13 and 14.

STANDARD AND SPECIFICATIONS

FOR

CRITICAL AREA STABILIZATION
(With Mulching Only)

Definition

Applying plant residues or other suitable materials not produced on the site to the soil surface.

Purpose

To conserve moisture; prevent surface compaction or crusting; reduce runoff and erosion; control weeds; and help establish plant cover.

Conditions Where Practice Applies

On graded or cleared areas (not to finished condition) which are subject to erosion for 6 months or less; where seedings may not have a suitable growing season to produce an erosion retardant cover, but which can be stabilized with a mulch cover.

SPECIFICATIONS

I. Site Preparation

A. Prior to mulching, install needed erosion control practices such as diversions, grade stabilization structures, berms, dikes, level spreaders, grassed waterways and sediment basins.

B. Final grading is not required prior to mulching. However, mulching may be applied after final grade is reached.

II. Mulching

A. Materials and Amounts

1. Straw - Straw shall be unrotted small grain straw applied at the rate of 1-1/2 to 2 tons per acre, or 70 to 90 pounds per 1,000 sq. ft. Mulch materials shall be relatively free of all kinds of weeds and shall be free of prohibited noxious weeds which are: Canada thistle, Johnsongrass and quackgrass.

Spread uniformly by hand or mechanically. For uniform distribution of hand spread mulch, divide area into approximately 1,000 sq. ft. section and place 70-90 lbs. of mulch in each section.

2. Asphalt emulsion or cutback asphalt at 600 to 1,200 gallons per acre. This is suitable for a limited period of time where travel by people, animals or machines is not a problem.

3. Synthetic soil stabilizers may be used according to manufacturers recommendations--under suitable conditions.

4. Mulch nettings such as jute or excelsior blanket may be used. Staple to surface in waterways and on steep slopes. Lighter materials of paper, plastic and cotton mulch nettings may be used where erosion hazard is not severe. If area is to be mowed, do not use metal staples.

5. Wood chips at the rate of approximately 6 tons per acre or 275 lbs. per 1,000 sq. ft. may be used when available and when feasible to use.

6. Crushed rock, stones, gravel or shale blankets. Apply at rate of 20 to 100 tons per acre or 900 to 4,500 lbs. per 1,000 sq. ft. with coarsest material applied at the highest rate.

B. Mulch anchoring shall be accomplished immediately after mulch placement to minimize loss by wind or water. This may be done by one of the following methods, depending upon size of area, erosion hazard, and cost. On sloping land, practice No. 3 below, should be done on the contour wherever possible. Applies to straw and to wood chips on more ctitical sites, except "tracking" should be done up and down the slope with 1-1/2" cleats making grooves across the slope.

1. Peg and Twine - Drive 8 to 10-inch wooden pegs to within 2 to 3 inches of the soil surface every 4 feet in all directions. Stakes may be driven before or after applying mulch. Secure mulch to soil surface by stretching twine between pegs in a criss-cross within a square pattern. Secure twine around each peg with two or more round turns.

2. Mulch Nettings - Staple lightweight biodegradable paper, plastic or cotton netting over the mulch according to manufacturer's recommendations. Netting is usually available in rolls 4 feet wide and up to 300 feet long.

3. Mulch Anchoring Tool - (not a disc) - A tractor drawn implement designed to punch and anchor mulch into the surface 2 inches of soil. This practice affords maximum erosion control but is limited to flatter slopes where equipment can operate safely, primarily used on steeper than 3:1 cut and fill slopes to cut the mulch into the soil with bulldozer cleats.

4. Liquid Mulch Binders

Applications of liquid binders should be heavier at edges where wind catches mulch, in valleys, and at crests of banks. Remainder of area should be uniform in appearance. Caution should be used with asphalt in residential and similar areas.

a. Cutback asphalt - rapid curing (RC-70, RC-250 and RC-800) or medium curing (MC-250 or MC-800). Apply 5 gallons per 1,000 sq. ft. or 200 gallons per acre on flat areas and on slopes less than 8 feet high. On slopes 8 feet or more high, use 8 gallons per 1,000 sq. ft. or 348 gallons per acre.

b. Emulsified asphalt - (SS-1, CSS-1, CMS-2, MS-2, RS-1, RS-2, CRS-1, and CRS-2). Apply 5 gallons per 1,000 sq. ft. or 200 gallons per acre on flat areas and on slopes less than 8 feet high. On slopes 8 ft. or more high, use 8 gallons per 1,000 square feet or 348 gallons per acre.

All asphalt designations are from the Asphalt Institute Specifications.

c. Synthetic binders - Synthetic binders such as Curasol, DCA-70, Petroset and Terra Tack may be used at rates recommended by the manufacturer to anchor mulch material.

Note: All names given above are registered trade names. This does not constitute a recommendation of these products to the exclusion of other products.

References

1. USDA - Soil Conservation Service Field Office Technical Guides.

2. Mulches for Wind and Water Erosion Control, USDA, ARS 41-84, July 1963.

3. Applied Mulches and Mulching, USDA, ARS Special Report, ARS 22-71, August 1961.

Note: Maryland Water Resources Administration has developed an audiovisual program, "Temporary Soil Stabilization", which relates to this subject.

STANDARD AND SPECIFICATIONS

FOR

CRITICAL AREA STABILIZATION
(With Bermudagrass)

Definition

Stabilizing silt producing areas by establishing long-term stands of bermudagrass.

Purpose

To stabilize the soil; to reduce damage from sediment and runoff to downstream areas. Enhance natural beauty.

Conditions Where Practice Applies

On hot, droughty, graded areas which are subject to erosion or traffic, and where a long-lived, warm-season grass cover is desired. Northern Coastal Plain and Atlantic Coast Flatwoods Land Resource Areas 1/.

SPECIFICATIONS

Vegetation cannot be expected to provide an erosion control cover and prevent soil slippage on a soil that is not stable due to its structure, texture, water movement or excessive slope.

Minimum Soil Conditions Needed for the Establishment and Maintenance of a Long-Lived Vegetative Cover:

A. Sufficient pore space to permit adequate root penetration.

B. The soil shall be free from any material harmful to plant growth.

C. If these minimum conditions cannot be met, see specification, Topsoiling (57.01).

I. Site Preparation

A. Install needed erosion control practices such as interceptor dikes, berms and spreaders, contour ripping, erosion stops, channel liners and sediment basins.

B. Grade as needed and feasible to permit the use of conventional equipment for seedbed preparation, planting, and maintenance.

II. Seedbed Preparation

'Tufcote' and 'Midland' bermudagrass varieties can be established by planting sprigs or plugs. 'Tufcote' sod is available. The seedbed will have to be loose enough to enable proper placement and firming of plants in the soil.

The seedbed must be free of weeds and other plants. Tillage to remove weeds and to work in lime and fertilizer will usually be sufficient for seedbed preparation.

III. Soil Amendments

A. Lime and fertilize according to soil tests. Lime and fertilizer needs can be determined by a soil testing laboratory, such as the University of Maryland Soil Testing Laboratory.

B. In lieu of soil test results, apply 2 tons dolomitic limestone, 400 pounds 38-0-0, Ureaform fertilizer, and 600 pounds 0-20-20 fertilizer, or equivalent, per acre before planting. Harrow or disc lime and fertilizer uniformly into the soil to a minimum depth of 3 inches on slopes less than 3 to 1. On slopes of greater than 3 to 1 grade, the lime and fertilizer shall be worked in as directed by the contracting officer. On sloping land, the final harrowing or discing operation should be on the contour wherever feasible. No attempt should be made to drag any disced area to make the soil surface very smooth after discing. At time of planting, apply 500 pounds 10-20-20 fertilizer, or equivalent, per acre.

IV. Adaptation

A. Bermudagrass is a warm-season grass which grows well in hot, droughty areas, but 'Tufcote' is susceptible to winterkill in the Piedmont region. 'Midland' bermudagrass is more winter hardy.

Two varieties are recommended. 'Tufcote' and 'Midland'. 'Tufcote' is a low growing, turf-type variety. It should be used on sites which will be maintained as a turf (with frequent, close mowing). 'Midland' is a taller growing type. It requires less frequent mowing.

V. Planting Methods

These bermudagrasses may be planted as stolons or rhizomes or plugged. 'Tufcote' may be sodded. (If established as sod, follow standards and specifications for Critical Area Stabilization, With Sod.)

The seedbed should be moist at planting time and soil temperature should be at least 50°F. The optimum period for establishment is from May 15-July 15 for all types of plantings. Plugs may be planted from April 15 to August 15.

Good soil moisture must be maintained for the first two weeks following planting, thus, supplemental irrigation may be required. Competitive weed growth during the first season must be controlled by mowing or herbicide. 2,4-D at the rate of 3/4 pound/A will help control broad-leafed weeds. For best results, apply herbicide when weeds are 4-6 inches high.

CAUTION: Pesticides can be injurious to humans, domestic animals, beneficial insects, desirable plants, and fish or other wildlife--if not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.

A. Sprigging

1. Rhizomes

A bermudagrass rhizome is a small section of underground stem from the plant, 3 to 5 inches long with at least one node. Rhizomes are planted deep with the node about 2 inches below the ground. If leaves are present, best results are obtained if leaf tips are above ground. They may be planted by hand or with a transplanter.

The recommended spacing of rhizomes is 18"x 24" (about 30 bu/A) on gentle slopes, and 18"x 18" (40 bu/A) where erosion hazard is greater. During a normal growing season, both spacings will provide a complete cover by the end of the first growing season. The closer spacing not only helps control erosion but will give more rapid cover.

2. Stolons (Runners)

Stolons or runners are above ground stems that spread by covering the soil surface. These may be harvested and used as planting material. They should be planted 2-4 inches deep with the leaf tips left above ground. They should be planted at a rate of 2-7 bushels per 1000 square feet with a maximum spacing of 18"x 24". Closer spacing will give faster coverage.

B. Plugging

Using 4" diameter plugs from established stands is also a good method of planting. One square foot of grass will plug one square yard of 12" centers. 540 square yards will be needed for an acre. 180 square yards will be needed per acre for an 18" x 24" spacing. Plant plugs 2" deep with topgrowth flush with the surface and leaves exposed. They should be firmed with the heel of a shoe, a press wheel or a tractor wheel.

VI. Maintenance

A. Irrigation - For maximum growth and spread, provide supplemental water as needed during the establishment year. From then on, little or no irrigation will be required.

B. Mowing - For turf-type maintenance, 'Tufcote' may be mowed to a 1-inch height although normal mowing height is 2 inches. For low maintenance areas, 'Midland' is well-adapted but 'Tufcote' may be used. One mowing is recommended when the grass becomes 12 to 18 inches tall or when the lower growing variety reaches 6 inches tall. Weeds should be mowed when they become a problem and shade the bermudagrass.

C. Fertilization - For turf-type management, higher rates of nitrogen are required. Apply 200 lbs. per acre (5 lbs. per 1,000 sq. ft.) of 20-10-10 or equivalent fertilizer May, July 1 and same amount of 0-10-10 September 1.

For low maintenance programs, apply 400 lbs. of 20-10-10 in late May. This is applicable only to 'Midland' bermuda.

References

1. Decker, A. Morris. Midland Bermudagrass, Bulletin 465, University of Maryland, Agricultural Experiment Station, January 1959.

2. Deal, Elwyn E. and Newcomer, Joseph L., Agronomy Mimeo No. 70, University of Maryland, Agronomy Department, May 1967.

3. USDA, Soil Conservation Service Field Office Technical Guides.

1/ Areas in Maryland below the Piedmont.

Reference: USDA, Soil Conservation Service Agriculture Handbook 296, "Land Resource Regions and Major Land Resource Areas of the United States."

STANDARD AND SPECIFICATIONS

FOR

CRITICAL AREA STABILIZATION
(With Sod)

Definition

Stabilizing silt-producing areas by establishing long-term stands of grass with sod.

Purpose

To stabilize the soil; reduce damage from sediment and runoff to downstream areas; enhance natural beauty.

Conditions Where Practice Applies

On exposed soils that have a potential for causing off-site environmental damage where a quick vegetative cover is desired; on sites which can be maintained with ground equipment. (2:1 or flatter slopes)

SPECIFICATIONS

1. Class of turfgrass sod shall be Maryland or Virginia State Certified, or Maryland or Virginia State approved sod.

2. Sod shall be machine cut at a uniform soil thickness of 3/4 inch, plus or minus 1/4 inch, at the time of cutting. Measurement for thickness shall exclude top growth and thatch.

3. Standard size sections of sod shall be strong enough to support their own weight and retain their size and shape when suspended vertically from a firm grasp on the upper 10% of the section.

4. Individual pieces of sod shall be cut to the suppliers width and length. Maximum allowable deviation from standard widths and lengths shall be 5%. Broken pads and torn or uneven ends will not be acceptable.

5. Sod shall not be harvested or transplanted when moisture content (excessively dry or wet) may adversely affect its survival.

6. Sod shall be harvested, delivered and installed within a period of 36 hours. Sod not transplanted within this period shall be inspected and approved by the contracting officer or his designated representative prior to its installation.

I. Site Preparation

Fertilizer and lime application rates shall be determined by soil tests. Under unusual circumstances where there is insufficient time for a complete soil test and the contracting officer agrees, fertilizer and lime materials may be applied in amounts shown under B. and C., below.

A. Prior to sodding, the surface shall be cleared of all trash, debris, and of all roots, brush, wire, grade stakes and other objects that would interfere with planting, fertilizing or maintenance operations.

B. Where the soil is acid or composed of heavy clays, ground limestone shall be spread at the rate of 100 pounds per 1,000 square feet. In all soils 30 pounds of 5-10-5, or equivalent, per 1,000 square feet shall be uniformly applied and mixed into the top 3 inches of soil with the required lime.

C. Slow release nitrogen at the rate of 3.5 lbs. N/1000 square feet shall be applied to the prepared soil just prior to sod installation. This material shall be approximately 1/3 immediately available and 2/3 water insoluble nitrogen. Urea formaldehyde (UF) and isobutylidene urea (IBDU) meet these standards.

II. Sod Installation

A. During periods of excessively high temperature the soil shall be lightly irrigated immediately prior to laying the sod.

B. The first row of sod shall be laid in a straight line with subsequent rows placed parallel to and tightly wedged against each other. Lateral joints shall be staggered to promote more uniform growth and strength. Insure that sod is not stretched or overlapped and that all joints are butted tight in order to prevent voids which would cause air drying of the roots.

C. On sloping areas where erosion may be a problem, sod shall be laid with the long edges parallel to the contour and with staggered joints. Secure the sod by tamping and pegging or other approved methods.

D. As sodding is completed in any one section, the entire area shall be rolled or tamped to insure solid contact of roots with the soil surface. Sod shall be watered immediately after rolling or tamping until the underside of the new sod pad and soil surface below the sod are thoroughly wet. The operations of laying, tamping and irrigating for any piece of sod shall be completed within eight hours.

III. Sod Maintenance

A. In the absence of adequate rainfall, watering shall be performed daily or as often as deemed necessary by the inspector during the first week and in sufficient quantities to maintain moist soil to a depth of 4 inches. Watering should be done during the heat of the day to help prevent wilting.

B. After the first week, sod shall be watered as necessary to maintain adequate moisture and insure establishment.

C. First mowing should not be attempted until sod is firmly rooted. No more than 1/3 of the grass leaf shall be removed by the initial cutting or subsequent cuttings. Grass height shall be maintained between 2 and 3 inches unless otherwise specified.

D. Maintenance of established sod should follow specifications outlined in table 54-1.

References

1. Guideline Specifications, Soil Preparation and Sodding. MD-VA. Pub. #1. Cooperative Extension Service, University of Maryland-Virginia Polytechnic Institute. Revised 1973.

2. Guideline Specifications for Sodding. American Sod Producers Association, Inc. New Brunswick, N. J.

3. USDA, Soil Conservation Service Field Office Technical Guides.

Note: Maryland Water Resources Administration has developed an Audiovisual Training Program, "Vegetative Soil Stabilization", which relates to this subject.

TABLE 54-1

Maintenance Fertilization for Permanent Sod
Use Soil Test Recommendations or Rates Shown Below

Seeding Mixtures	Formulation*	Lbs/Ac.	Lbs/1000 sq.ft.	Time	Mowing
'Ky-31' tall fescue and)	20-10-10	250	6.75	Sept. 1 - Oct. 1	Mow no closer than 2 inches for bluegrass and 3 inches for fescue.
Kentucky bluegrass-)	20-10-10	250	6.75	30 days later.	
Red fescue mixture)	20-10-10	250	6.75	December.	
	20-10-10	85	2.25	May 20 - June 30, as needed.	
Bermudagrass, 'Tufcote'	20-10-10	200	5.00	May 1, July 1	1-2"
	0-10-10	200	5.00	August 15	

*Equivalent amounts of plant food may be applied with other formulations.

STANDARD AND SPECIFICATIONS

FOR

CRITICAL AREA STABILIZATION
(With Ground Covers, Vines, Shrubs and Trees)

Definition

Planting vegetation such as trees, shrubs, vines, and ground covers on critical areas.

Purpose

To stabilize area; to reduce damages from sediment and runoff to downstream areas; to enhance natural beauty.

Conditions Where Practice Applies

Graded or cleared areas subject to erosion where a permanent, long-lived vegetative cover other than turf is desired.

SPECIFICATIONS

An attempt has been made to list some plants known to be suitable for erosion control and possess esthetic value. This list is neither inclusive or exclusive. The list includes plants which establish easily on difficult sites as well as plants that will require some site improvement before they will grow satisfactorily.

These plants cannot be expected to provide an erosion control cover and prevent soil slippage on a soil that is not stable due to its texture, structure, water movement or excessive slope.

Ground covers are not necessarily low-maintenance plants. In general, they are more difficult to establish than turf. Plants included in this list respond favorably to careful treatment during the period of establishment.

Planting Time

Early spring. This allows for the maximum root and top development to check erosion and allow the plant to become established before winter. Woody plants may be planted during the fall of year, if given special care during the winter.

Soil Preparation

For short slopes, small areas, and mass plantings with close spacings, apply a commercial granular fertilizer such as 5-10-10 and organic supplement such as composted cow manure, peat or well-rotted sawdust, and work into the soil prior to planting. Fertilizer rate - 3 to 5 lbs. per 100 sq. ft. The organic material needed will depend upon the soil and plant being used. Plants such as pachysandra require a high rate of organic material, about a 2-inch layer worked into the root zone. Depending on the soil type and steepness of slope, the depth of soil working will vary from 4 to 6 inches.

For steep slopes and large area plantings, working up the entire planting area would be impractical and would probably induce erosion. Center hole planting, a hole dug for each plant, would be more desirable. If the soil on the slope is poorly suited to the species being planted, incorporate organic material into the planting hole. Whether organic material in needed or not, fertilize each plant at the rate of one ounce per plant of some complete fertilizer such as 10-10-10. Mix fertilizer with soil below the roots of the plants.

Another alternative is to add to the planting hole a sandy loam soil mixed with peat, composted cow manure and cocoa shells, or well-rotted sawdust at the rate of 1:1 or 2:1.

The entire planted slope shall be covered with a protective mulch such as excelsior, wood chips, straw or wood pulp fiber to conserve moisture and control erosion. Weeds shall be controlled by pulling or other acceptable means. Where fresh woodchips, wood shavings or sawdust are used as mulches or to add organic material to planting bed, a slow release fertilizer such as 7-40-6, 38-0-0 or organic forms should be used.

Where erosion hazard is very high, heavy jute metting stapled to the slope will provide excellent erosion control, as will landscape mats of excelsior or fiber glass.

Where individual plants are planted, a temporary cover crop of annuals will be used for erosion control until planted materials offer protective cover. (See standards and specifications for temporary seeding).

Maintenance

Some watering, remulching and fertilizing may be required of a new planting during the period of establishment. Cultivation is not recommended. This will encourage erosion and cause root injury. Competing weeds will be controlled.

If a controlled release fertilizer was used at time of planting, additional fertilizing may not be necessary for several years. Otherwise, fertilize plantings during the spring of the second growing season and thereafter as needed, using 2 to 3 pounds of a granulated commercial fertilizer such as 5-10-10 per 100 square feet.

	GROUND COVER PLANTS	Winter Aspect Evergreen Semievergreen Herbaceous	Major Land Resource Areas*	Site Conditions Required	Light Prefers Tolerates Sun	Shade	Range of Height (inches)	Spread Rapid Medium Slow	Spacing Between Plants (inches)	Time to Form Cover (yrs.)	Area (size Limitations Large -over 500 sq. ft.	Bloom Distinct Indistinct Color
1.	Bugle Weed (Ajuga reptans)	S	All	Pref. mod. moist soils. Tolerates wet soils.	T	P	4-8	R	9-12	1-2	None	D Blue-Purp.
2.	Lilyturf (Liriope muscari)	E	All	All but droughty soils.	T	P	10-15	M	10-12	2	None	I White
3.	Tawny daylily (Hemerocallis fulva)	H	All	Pref. moist soils, seepage areas. Tolerates all but droughty soils.	P	T	18-24	S	12-24	2-3	None	D Orange
4.	Lily-of-the-valley (Convallaria majalis)	H	All	Pref. rich moist soils. Tolerates acid soils.	-	P	6-8	M	6-8	2	None	D White
5.	Dwarf polygonum (Polygonum reynowtria)	H	All	Pref. moist soils. Tolerates droughty acid soils, rocky slopes.	P	-	12-15	R	18	1	Large	D Pink-Red
6.	Canby Pachistima (Pachistima canbyi)	E	All	Pref. slightly acid. moist, fertile soils	P	T	8-12	M	12-18	2	None	I Red
7.	Creeping Thyme (Thymus serpyllum)	E	All	Pref. well-drained soils, tolerates poor droughty soils	P	T	2-4	M	8-10	2	None	D Rose
8.	Wineleaf Cinquefoil (Potentilla tridentata)	S-E	All	Pref. well-drained soils. Tol. acid moist soils to dry poor soils.	P	T	6-12	R	12-18	2	None	I White
9.	Japanese Spurge (Pachysandra terminalis)	E	All	Pref. moist soils with high organic matter.	-	P	6-8	M	6-8	2	None	I White
10.	Baltic English Ivy (Hedra helix baltica)	E	All	Pref. moist soils with high organic matter	T	P	6-12	M-R	18-24	2	Large	I White
11.	Common Periwinkle (Vinca minor)	E	All	Pref. moist fertile soils. Tolerates acid moist soils.	T	P	6-8	R	12-18	1-2	None	D Blue to Wht
12.	Bearberry (Arctostaphylos uva-ursi)	E	All	Pref. droughty acid sands.	P	T	4-8	S	12-24	2-3	None	I Wht. to Pink
13.	Littleleaf cotoneaster (Cotoneaster dammeri radicans)	E	All	All but droughty and wet soils.	P	-	10-15	M	12-18	2	None	I White
14.	Crownvetch (Coronilla varia)	H	All	All well-drained soils except coarse sands; drought tolerant.	P	T med.	12-24	S	12-18 (usually seeded)	2-3	None	D Wht. - Purp.

NOTES

1. Compact ground cover. Thrives in light shade and northerly exposure. Dark green or purple foliage with attractive spring flowers. a/
2. Forms dense deep green grasslike turf. Withstands occasional mowing but limited foot traffic. Provides good erosion control with little maintenance. a/
3. Excellent for erosion control contour bands on steep slopes. Mass plantings need companion cover crop. Long-lived. b/
4. Forms long-lived dense green erosion control mat, with fragrant spring flower. Dormant in winter. c/
5. Very aggressive, long-lived plant. Underground runners may invade border areas. Red autumn foliage. Dies to ground in winter. a/
6. A prostrate shrub with branches often rooting to form solid mass of fine foliage. Very hardy, requiring minimum maintenance. d/
7. Forms low mass of fragrant, tiny gray foliage. Above ground spreader. Thrives in rocky areas. c/
8. An attractive evergreen species which forms a thick mat. Branches erect, spreading, c/ f/
9. Forms thick carpet of yellow-green foliage, even under pines. On open locations, leaves may burn in winter. Spreads by underground stems. a/
10. Forms dense green mat with trailing root stems. Stands severe cold. Better than English ivy. Easy to cultivate. d/
11. Forms glossy green long-lived cover requiring little maintenance. Easy to establish. Excellent soil stabilizer. c/ d/
12. Forms attractive thick prostrate mat of trailing stems. Established from potted plant only. Salt tolerant. Excellent sand stabilizer. d/
13. A prostrate shrub with long, trailing, often rooting branches. Forms tough cover. Will cover rocky slopes. d/ e/ f/ g/
14. Straggling or ascending smooth herb. South or north exposures. c/ f/

*MAJOR LAND RESOURCE AREAS: 127 - Eastern Allegheny Plateau and Mountains. 147 - Northern Appalacian Ridges and Valleys. 130 - Blue Ridge. 148 - Northern Piedmont. 149 - Northern Coastal Plain. 153 - Atlantic Coast Flatwoods.

Propagated by: a/ stolons, b/ tubers, c/ plant division, d/ cuttings e/ layering, f/ seed, g/ grafting.

	VINES	Winter Aspect Evergreen Semievergreen Deciduous	Major Land Resource Areas*	Site Conditions Required	Light Prefers Tolerates Sun	Shade	Range of Height (inches) Spread (feet)	Spread Rapid Medium Slow	Spacing Between Plants (feet)	Time to Form Cover (yrs.)	Area (size) Limitations Large -over 500 sq. ft.	Bloom Distinct Indistinct Color
1.	Wintercreeper (Euonymus fortunei) colorata reticulatus and minimus	S-E	All	Pref. well drained soils. Tol. acid, moist soils.	T	P	6-12 / 10+	M-R	1-2	2-3	Large areas	I Green
2.	Fiveleaf Akebia (Akebia quinata)	S-E	All	Mod. moist soils with high organic matter.	P	T	6-8 / 15+	R	2-3	2	Large areas	D Red
3.	Halls Japanese Honeysuckle (Lonicera Japonica halliana)	S-E	All	Nearly all soils, stony rough slopes. Tol. moist acid soils.	P	T	12-18 / 25+	R	2-3	2	Large areas	D Wh.-Yel.
4.	Henry Honeysuckle (Lonicera henryi)	S-E	All	Nearly all soils - stony rough slopes. Tol moist acid soils.	P	T	12-18 / 25+	R	2-3	2	Large areas	D Reddish
5.	Memorial Rose (Rosa Wichuraiana)	S	All	All but poorly drained soils. Tol. stony, rough slopes.	P	-	12-24 / 20+	R	2-3	2	Large areas	D White
6.	Max Graf Rose (Rosa wichuraiana, max graf)	S	All	All but poorly drained soils. Tol. stony, rough slopes.	P	-	12-24 / 20+	R	2-3	2	Large areas	D Pink
7.	Virginia Creeper (Parthenocissus quinquefolia)	D	All	Pref. medium to well drained soils. Tol. dry soils, rough slopes	P	T	10-20 / 15	R	2-3	2	Large areas	I Greenish
8.	Korean Bittersweet (Celastrus orbiculata)	D	All	Pref. heavy moist soils. Tol. dry soils, rocky slopes.	P	T	24-48 / 20+	R	2-3	2	Large areas	I Greenish
9.	Oriental Bittersweet (Celastrus orbiculata)	D	All	Pref. heavy moist soils. Tol. dry soils, rocky slopes.	P	T	24-48 / 20+	R	2-3	2	Large areas	I Greenish
10.	Common Moonseed (Menispermum canadense)	D	All	Pref. well drained soils. Tol. moist to wet soils.	P	T	12-18 / 12+	R	2-3	1	Large areas	I Greenish
11.	Kudzu (Pueraria thumbergiana)	D	All but Mountains	Pref. well drained soils. Tol. all but wet soils.	P	T	18-36 / 75	R	4-6	1	Very Large areas	D Purple

NOTES

1. Forms weed free mat, tacking at nodes. Less subject to scale than other euonymuses. Frost turns foliage reddish purple. Covers steep slopes. d/

2. A vigorously growing twiner with rich dark green, clean foliage, somewhat like honeysuckle. Covers steep slopes. Wlll climb. d/ f/

3. A rampant grower requiring some control shearing. Long lived with fragrant bloom. Do not plant near trees; will climb. Covers steep slopes. c/, d/

4. Similar in many ways to L. japonica halliana, may be more hardy with showy green winter foliage; not as vig. c/, d/

5. A strong grower that forms a prostrate tangled thorny traffic resistant cover. Requires occasional clipping and dead cane removal. Covers steep slopes. d/

6. A prostrate, strong growing vine similar to R. wichuriana, but with bright pink flowers. d/

7. A vigorous clinging vine of loose habit. Showy scarlet fall foliage, black berries, Will climb. d/ e/ f/

8. A twining vine with spines which make it a good barrier plant. Fruit smaller than other bittersweets. (Male and female plants). c/ e/f/

9. A scrambling type vine with branched woody stems. Showy yellowish orange autumn fruit (male and female plants) c/ e/ f/

10. A rampant ground cover of ivy-like foliage usually killed to the ground in winter, but quickly grows back in spring. Very aggressive. d/f/g/

11. The fastest growing of all woody vines. A coarse textured vine that must be kept prostrate and confined. To not plant near trees. d/ f/

Propagated by: c/ plant division, d/ cuttings, e/ layering, f/ seed, g/ transplants.

*See bottom of first page of table.

	EVERGREEN SHRUBS	Major Land Resource Areas*	Site Conditions Required	Light Prefers Tolerates Sun	Shade	Growth Rapid Medium Slow	Spacing Between Plants (feet)	Time to Form Cover (yrs.)
	Needle Evergreen - up to 3 feet							
1.	Creeping Juniper (Juniperus horizontalis)	All	Pref. moist, slightly acid sandy soils. Tol. droughty banks.	P	T	M	3-4	2-3
2.	Sargent Juniper (Juniperus chinensis sargenti)	All	Pref. moist, slightly acid sandy soils. Tolerates dry soils.	P	-	M	3-4	2-3
3.	Shore Juniper (Juniperus conferta)	149 153	Sand dunes and seashore Tolerates inland droughty sand.	P	-	M	3-4	2-3
4.	Japanese Juniper (Juniperus procumbens)	All but Mountains	Sandy and loamy moderately moist soil.	P	-	R	3-4	2
5.	Canada Yew (Taxus canadensis)	All	Pref. moist acid soils.	T	P	S	2-3	2-3
	Broadleaf Evergreen - up to 3 ft.							
6.	Prostrate Cotoneaster (Cotoneaster horizontalis)	All but Mountains	Pref. well drained soils. Tolerates poor, dry soils.	P	T	M	2-3	2-3
7.	Bearberry Cotoneaster (Cotoneaster dammeri)	All but Mountains	Pref. well drained soils. Tolerates dry, rocky slopes.	P	T	M	2-3	2-3
	Needle Evergreen 4 to 6 feet							
8.	Pfitzer's Juniper (Juniperus chinensis pfitzeriana)	All	Prefers well drained soils. Tolerates droughty soils.	P	T	R	3-4	2
9.	Japanese Yew (Taxus cuspidata)	All	Moist well drained soils with moderate organic matter.	T	P	M	3	2-3

NOTES

1.	A low creeping very hardy shrub with attractive trailing branches of dark green to blue-gray foliage. Covers steep sunny slopes.
2.	A low prostate, creeping shrub with steel-blue foliage. Forms dense mat. Tolerates salt spray.
3.	A procumbent shrub especially adapted for seashore planting; salt tolerant; requires organic supplement for establishment.
4.	A handsome hardy low spreading shrub with ascending branches; free from disease and insect problems.
5.	A very hardy low preeading , straggling, long-lived shrub. Showy autumn scarlet fruit.
6.	An attractive shrub with flat horizontal branches. Bright red autumn foliage and berries. Excellent for short, steep, rocky slopes. Do not use bare root stock.
7.	A prostrate shrub with long, trailing, often rooting, branches. Red berries. Covers steep rocky slopes. Susceptible to fire blight. Do not use bare root stock.
8.	A broad, often flat-topped, wide-spreading shrub. Long-lived, and very hardy.
9.	A handsome, compact, low shrub with dark green foliage and red fleshy berries in autumn. Long lived.

*See bottom of first page of table.

	DECIDUOUS SHRUBS	Major Land Resource Areas*	Site Conditions Required	Light Prefers Tolerates Sun	Shade	Growth Rapid Medium Slow	Spacing Between Plants (feet)	Time to Form Cover (yrs.)	Bloom Distinct Indistinct Color
	Up to 3 ft.								
1.	Arnold Dwarf Forsythia (Forsythia arnoldi)	All	Any well drained soils.	P	-	R	2-3	2	I Yellow
2.	Fragrant Sumac (Rhus aromatica)	All	Any well drained soil. Tolerates acid soils.	P	-	R	2-3	2	I Yellow
3.	Hardhack Spirea (Spirea tomentosa)	All	Well to imperfectly drained poor soils. Tol. droughty soils.	P	-	R	2-3	2	D Rose
4.	Black Chokeberry (Aronia melanocarpa)	All	Pref. moist soils. Tol. poorly drained acid soils.	T	T	M	2-3	2-3	D White
5.	Scotch Rose (Rosa spinosissima)	All	Pref. rich loamy sand. Tolerates droughty sand.	P	T	R	2-3	2	D Pink
6.	Dwarf Pussy Willow (Salix tristis)	All	Any well drained soil. Tol. poorly drained soils.	T	T	M	2	2	-
7.	Blue artic Willow (Salix purpurea nana)	All	Any well drained soil. Tol. poorly drained soils.	P	T	R	3	3	-
	4 to 6 feet								
8.	Siebold Forsythia (Forsythia suspensa sieboldi)	All	Any well drained soil. Tol. stony, rough slopes.	P	-	R	3-4	2	D Yellow
9.	Bristly locust (Robinia fertilis)	All	Any well drained soil. Excellent for droughty soils, rocky slopes.	P	-	R	3-4	2	D Purple
10.	Virginia Rose (Rosa virginiana fertilis)	All	Pref. well-drained heavy soils. Tolerates droughty soils.	P	T	R	3-4	2	D White
11.	Snowberry (Symphoricarpos albus)	All	Well drained to imperfectly drained soils.	T	P	R	2-3	2	I Pink
12.	Coralberry (Symphoricarpos orbiculatus)	All	Well drained to imperfectly drained soils.	T	T	R	2-3	2	I White
13.	Billard Spirea (Spirea billiardi)	All	Any well drained soil.	T	T	R	2-3	2	D Rose
14.	Red-osier dogwood (Cornus stolonifera)	All	Moist to poorly drained soils	P	T	R	2-3	2	D White
15.	Bayberry (Myrica pensylvanica)	All	Prefers poor, acid sandy soils. Tol. well drained to imperfectly drained soils.	P	T	S	3	3	I —

NOTES

1.	A true dwarf shrub with drooping branches that root as they touch the ground.
2.	A low dense irregular spreading shrub. Forms colonies. Brilliant autumn foliage and fruit.
3.	An upright clump-type shrub with rooting branches. Good for naturalizing and clump plantings.
4.	A suckering shrub of loose habit with upright stems. Good woodland border plant. Black berries and red foliage in autumn.
5.	A low, dense, freely suckering, moundlike shrub. Thicket former. Profuse bloomer.
6.	A low shrub with slender clustered stems and gray foliage, and long, deep-set root.
7.	Dense twigs; can be sheared. Foliage has blue cast.
8.	A vigorous shrub with pendulous, spreading, rooting branches.
9.	A much branched thicket forming shrub. Spreads vigorously by underground suckers. Give plenty of space. Excellent soil stabilizer.
10.	Forms dense mat of erect stems. Foliage, fruit and stems scarlet in autumn. Spreads by underground stems. Clump or contour row plantings.
11.	A slender, loosely ascending shrub with showy white autumn fruit.
12.	A low, freely suckering shrub with slender upright, spreading branches. A clump former. Showy coral fruit. Excellent soil stabilizer.
13.	An Erect shrub which increases by underground stems to form a dense mass.
14.	A rather open-branched, somewhat spreading yet upright shrub. Forms thickets by stoloning. The branches, especially the new ones, are bright red. The pith is white.
15.	A symmetrical spreading shrub with aromatic deciduous to sub-persistent leaves and trailing, rooting branches. Showy waxy-gray berries. Male and female plants.

*See bottom of first page of table.

	DECIDUOUS SHRUBS	Major Land Resource Areas*	Site Conditions Required	Light Prefers Tolerates Sun	Shade	Growth Rapid Medium Slow	Spacing Between Plants (feet)	Time to Form Cover (yrs.)	Bloom Distinct Indistinct Color
	7 to 10 ft.								
1.	Gray Dogwood (Cornus racemosa)	All	Nearly all soils. Tolerates wet soils.	P	T	R	3-4	2	I White
2.	Japanese Barberry (Berberis thunbergi)	All	Pref. medium to well drained soils. Tol. sandy soils.	P	T	S	2-3	2-3	I Yellow
3.	Red Chokeberry (Aronia arbutifolia)	All	Tol. dry to somewhat poorly drained soils.	P	T	M	3-4	2-3	D White
4.	Ninebark (Physocarpus opulifolius)	All	Prefers well drained soils. Tolerates dry rocky soils.	P	-	R	3-4	2	D White
5.	Regels Border Privet (Ligustrum obtrusifolium regelianum)	All	Tolerates dry to medium well drained soils.	P	-	M	3-4	2-3	I White
	11 to 15+ ft.								
6.	Tatarian Honeysuckle (Lonicera tatarica)	All	Any well drained soil.	P	T	R	3-4	2	D White
7.	Staghorn Sumac (Rhus typhina)	All	Any well drained soil. Tolerates droughty soils.	P	-	M	4-5	2-3	I Yellow
8.	Shining Sumac (Rhus copallina)	All	Any well drained soil. Tolerates droughty soils.	P	-	M	4-5	2-3	I Yellow
9.	Cardinal Autumn Olive (Elaeagnus umbellata)	All	Dry to moderately well drained soils. Excellent for dry slopes.	P	-	R	4-5	2	I Yellow
10.	Amur Privet (Ligustrum amurense)	All	Moderately well drained to well drained soils.	P	-	R	4-5	2	I White
11.	Arrow-Wood (Viburnum dentatum)	All	Prefers well drained to moist soils.	P	T	R	4-5	2	D White

NOTES

1.	Bushy, spreading, stoloniferous shrub. Suckers freely. Colony former.
2.	A very twiggy, compact shrub with red autumn foliage and berries. Forms a deterrent to traffic. Thorns toxic to some people.
3.	A dependable shrub, open branched and suckering. Showy red fruit and foliage in autumn.
4.	A vigorous shrub with coarse twiggy recurving branches. Very hardy. Use in large plantings.
5.	A low growing hardy shrub with distinctive horizontal branching. Make attractive contour row plantings.
6.	A refined upright shrub free of disease and insects. Good for clump or contour row plantings.
7.	A straggling shrub with a flattish crown. Brilliant scarlet autumn foliage and fruit. Colony former for large areas.
8.	One of the most ornamental sumacs with brilliant red fall color. Colony former for large areas.
9.	A very hardy spreading shrub with silvery foliage and abundant red fruit. For large areas.
10.	A dense, pyramidal, upright shrub with stiffly upright, lateral twigs. Considerably hardier than California privet. Large areas.
11.	A vigorous bush, upright shrub which spreads from numerous basal shoots. Large areas - mass plantings.

*See bottom of first page of table.

	TREES	Winter Aspect Evergreen Deciduous	Major Land Resource Areas*	Site Conditions Required	Growth Rapid Medium Slow	Spacing Between Plants (feet)	Height Range (feet)
1.	Washington Hawthorn (Crataegus phaenopyrum)	D	All	Well drained to moderately well drained soils.	M	5-9	30
2.	European Black Alder (Alnus glutinosa)	D	All	Dry to poorly drained soils.	R	5-9	50+
3.	Japanese Larch (Larix leptolepis)	D	All	Well drained to moderately well drained soils.	R	5-9	50+
4.	Scotch Pine (Pinus sylvestris)	E	All	Dry to somewhat poorly drained soils.	R	5-9	50+
5.	Virginia Pine (Pinus virginiana)	E	All	Dry to moderately well drained soils.	R	5-9	50+
6.	Common Juniper (Juniperus communis)	E	All	Prefers limestone soils. Dry to moderately well drained soils.	S	4-6	25+
7.	Eastern Red Cedar (Juniperus virginiana)	E	All	Prefers limestone soils. Dry to moderately well drained soils.	S	5-7	50+
8.	Black Locust (Robinia pseudoacacia)	D	All	Wide range from rich, well drained to acid soils.	R	8-10	50+
9.	Loblolly Pine (Pinus taeda)	E	149 153	Moist to somewhat poorly drained flat soils. Useful on disturbed or dredged areas, especially where slight to moderate salinity is present.	R	5-9	50+
10.	White Pine (Pinus strobus)	E	All	Prefers rich, moist soils, especially heavy soils.	R	5-9	50+

NOTES

1.	Dense twiggy upright growth. Profuse red flowers. Brilliant autumn foliage. Red fruit lasts all winter.
2.	A small tree with spreading branches and a symmetrical ovoid to oblong top.
3.	A graceful deciduous conifer with short horizontal branches. Quickly lays down a ground cover of needles.
4.	Pyramidal when young, irregular shape when older. A very rugged conifer.
5.	A rugged conifer of open habit and sparse branching. A good litter producer on poor soils.
6.	A small conifer of pyramidal habit. A variable species.
7.	A densely pyramidal, often columnar conifer with scalelike foliage, female plant bears blue fruit. A long lived tree in full sun.
8.	Black locust is a widely used tree for covering large areas to be vegetated. It is not desirable to use close to homes, etc.
9.	Has spreading branches, the upper ascending, forming a compact round-topped head; branchlets yellowish brown, sometimes slightly bloomy. Develops a straight, clean trunk in stands.
10.	One of best pines for ornamental purposes. Must have plenty of room for growth. Also used for screens and windbreaks.

*See bottom of first page of table.

References

1.	Growing Ground Covers, USDA Home and Garden Bulletin No. 175.
2.	Autumn Olive, USDA, Soil Conservation Service Leaflet No. 458.
3.	Ground Cover Plants, Ext. Bull. 190, University of Maryland, College Park, Maryland.
4.	Evaluation of Woody Plants and Development of Established Procedures for Direct Seeding and/or Vegetative Reproduction AW 73-75-46, for Maryland State Highway Administration by USDA, Soil Conservation Service.
5.	USDA, Soil Conservation Service Field Office Technical Guides.

SECTION IV

STANDARDS AND SPECIFICATIONS

FOR

SPECIAL PRACTICES

STANDARDS AND SPECIFICATIONS
FOR
VEGETATIVE TIDAL BANK STABILIZATION

Definition

Stabilizing tidal banks or slopes adjacent thereto with adapted plants in conjunction with designed structures as needed.

Purpose

To control undesirable soil movement and loss from tidal banks and from higher adjacent slopes.

Conditions Where Practice Applies

1. Where eroding tidal banks and adjacent slopes can normally be stabilized without structures.

2. Where erosion needs to be controlled on tidal banks and adjoining slopes in support of tidal bank protection structures. (Technical guidance for design, installation and maintenance of shore erosion control structures is provided by the Maryland Department of Natural Resources, Annapolis, Maryland.)

PLANNING CONSIDERATIONS

The critical area for stabilizing eroding tidal banks is to control erosion at the toe of the slope. Once this is done, the upper slope can be vegetated. Toe stabilization is usually accomplished through the use of structures such as bulkheads and revetments, or groins, or a combination of these practices. These structures are designed to protect the shore from loss of soil by wind and current action, and in the case of groins, some sand can be trapped which gives a stabilizing effect to the immediate area.

There are sites with characteristics which permit use of economical measures such as sloping the bank and stabilizing it with vegetation. These site conditions include:

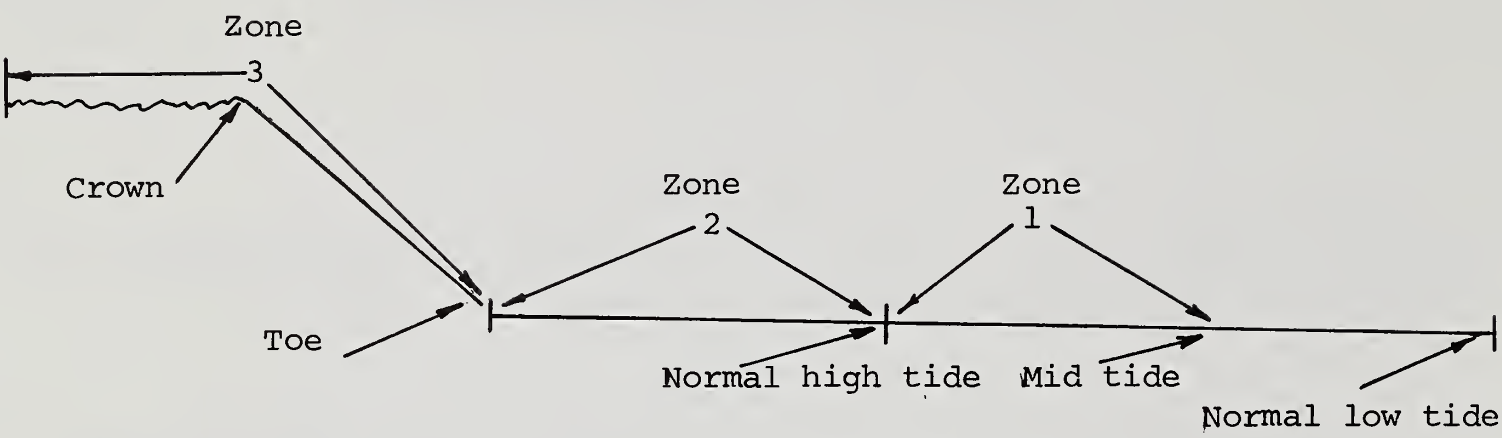
1. Evidence that at least one of the cordgrasses is invading the bank area.

2. Evidence that littoral drift is being transported past the location being planted. (Important)

3. Exposure to waves and currents is negligible.

4. Bank height does not exceed 10 feet.

VEGETATIVE ZONES
(Areas of Plant Adaptation)



Vegetative Zone 1

That area extending from mid tide to normal high tide.
This zone is submerged during normal high tides.
Soil composition may vary from coarse sand to compacted silt or clay.

Vegetative Zone 2

That area extending from normal high tide to toe of bank; or graded slope; or to the base of bulkhead or slope revetment, if an along-shore structure is employed.

This zone is subject to spray and periodic inundation.

Soil composition may vary from rather stable sandy material to shifting sands, and in some cases, silt or clay strata may be on or near the surface.

Vegetative Zone 3

That area extending from toe of bank or graded slope or from top of bulkhead, or slope revetment, if an along-shore structure is employed, to the crown and beyond.

This zone is subject to spray but seldom to flooding.
Soils may vary from droughty sands to heavy impervious clay materials.
There may be seepage spots, and in some cases, poor natural soil drainage.

SPECIFICATIONS
(Plants and their Establishment and Maintenance Requirements)

VEGETATIVE ZONE 1

This is the most difficult area in which to establish plants, due to wave and tidal action which tends to lift the new plantings before they become established. Planting in this area is usually restricted to fortifying and tying together existing vegetation, if present, into a continuous uniform stand.

The planting must be done during periods of low tide in trenches parallel to the shore line. The trenches should be approximately 6 inches wide and 8 inches deep (use square pointed shovel) with not over 2 feet between trenches. Sod of planting stock approximately 6 inches square and placed in a continuous tight band in the trench and securely tamped until they are lower than the existing soil surface. Use care in tamping sod so as not to injure top growth. A capping of jute netting can be used to anchor plants in place.

Plant Materials:

Brackish to saline sites: (5,000 to 42,000 parts per million)

Spartina alternaflora Loisel., smooth cordgrass. A long-lived erect stemmed perennial with a heavy mat of cordlike rhizomes which forms an excellent erosion resistant cover. Average height is 2 to 3 feet. Plant between April 1 and June 30. Grows best on organic or firm mineral soils. At higher elevations, *Distichlis spicata* (L.) Greene, seashore saltgrass may be used on saline sands to clays.

Brackish sites:

Juncus roemerianus Scheele, needlegrass rush. A smooth upright perennial with creeping root stocks. Average height 2 to 3 feet. Plant between April 1 and June 30.

Fresh to brackish sites:

Scirpus americanus Pers., three-square or American bulrush. A perennial with triangular stems. Spreads by rhizomes. Average height 2 to 3 feet. Plant between March 1 and May 1.

The above plants are not available commercially. It is best to secure them as close to the planting site as possible, since they are dug in sod pieces approximately 6 inches square and considerable weight is involved. Water transportation may be easier than over land transfer. If possible, dig sod with shallow (6 to 8 inches) root system. The sod will lift easier and contain a more compact root system than if dug from deeply rooted plants.

Fertilization

Commercial fertilization is impractical. Daily inundation supplies sufficient nutrients for plants in this zone.

Maintenance

Since this is the first line of defense against tidal and wave action on the shore, it is imperative that repairs be made promptly to prevent damaging washouts.

VEGETATIVE ZONE 2

This area may vary in width from a few feet to 50 or more feet. Often groins are needed to provide, or widen a protective beach by trapping littoral drift or to retard loss of an existing beach. It is desirable to have a distance of at least 15 feet between the normal high tide and the toe of the slope or base of along-shore structures, before starting vegetative stabilization.

Along "starved" shore lines (where there is little or no littoral drift) zone 2 is nonexistent. The most difficult area to vegetatively stabilize is where a light sand capping is deposited over layers of ferruginous sandstone or dense, slick, blue clay. There is little to no root penetration into these materials to form a bond against erosion.

Plant Materials and Establishment Techniques

Brackish and saline soils are usually found along the lower section of this zone, but may comprise the entire zone.

Spartina patens (Ait.) Muhl., Saltmeadow cordgrass. Grows best on firm, mineral soils. A perennial with erect slender stems, 2 to 3 feet in height, and aggressive, stout, cordlike, scaly rhizomes. Forms dense erosion resistant cover. Grows in salt content between 2,000 and 39,000 p.p.m. See note, page 56.07.

Planting stock can be secured from moist, sandy shoreline areas where the root mass is no deeper than 6 to 8 inches. Bundle bare rooted plants in moist burlap. Plant as soon after digging as possible between April 1 and June 30.

Planting. Pull clumps apart so as to have 3 to 5 stems per plant. Plant in rows parallel to the shoreline with not over 2 feet spacing between plants and between rows. Use a staggered planting pattern. Planting depth should be about 8 inches, approximately 2 inches deeper than original soil line. (Tiling spade is the best tool for hand planting.) Fertilize at time of planting with a controlled release fertilizer such as magnesium ammonium phosphate (7-40-6). Place 1 or 1-1/2 oz. in bottom of each planting hole. Compact soil firmly around each plant.

Saltmeadow cordgrass can be planted on heavier textured soils from the normal high tide line to an elevation of about 3 feet; on sandy saline soils to an elevation of about 10 feet. For fresh or moderately brackish moist sands to clays, seashore saltgrass may be substituted for saltmeadow cordgrass. Sandy soil and shifting beach sands are usually found along the upper section of this zone, especially between groins, and in some cases may comprise the entire zone.

Seeding

Apply seed uniformly at the rate of 40 to 60 pounds per acre with a cyclone seeder, drill, cultipacker seeder, or hydroseeder on a firm moist seedbed.

Where feasible, except when a cultipacker type seeder is used, the seedbed should be firmed following seeding operations to cover seed to a depth of 1/2 inch. Seeding periods - February 1 to May 1 and August 15 to October 15. Mulch slope with straw immediately after seeding (1-1/2 to 2 tons per acre). Apply and anchor mulch as outlined in standard and specification for mulching. Inspect seeded areas and make necessary repairs, replacements, and reseedings within the planting season, if possible.

Maintenance

Fertilize yearly, or as needed in the fall with 500 pounds per acre of 10-10-10 or its equivalent. Do not mow closer than 4 inches. Mowing not necessary except for weed control.

References

1. State of New York, "The Conservationist", April-May, 1971, pages 22-27.

2. Hill, David E. and Shearin, Arthur, "Tidal Marshes of Connecticut and Rhode Island, Conn. Agri. Exp. Station, Bulletin 709, February 1970.

3. Shore Erosion in Tidewater Maryland, 1949. Reprint from Bulletin 6, State of Maryland, Department of Natural Resources.

4. Slaughter, Turbit, "Vertical Protective Structures in Maryland Chesapeake Bay", Shore and Beach.

5. USDA, Soil Conservation Service Field Office Technical Guides.

Note: Environmental Concern, Inc. of St. Michaels, Maryland is producing various marsh plants which may be purchased or which they use for completing contract work. They are a non-profit organization.

STANDARD AND SPECIFICATIONS

FOR

TOPSOILING

Definition

Placement of topsoil over a prepared subsoil prior to establishment of vegetation.

Purpose

To provide a suitable soil medium for vegetative growth on areas with low moisture, low nutrient levels, low pH, or the presence of toxic materials.

Conditions Where Practice Applies

This practice is recommended for sites of 2:1 or flatter slopes where:

1. The texture of the exposed subsoil or parent material is not suitable to produce adequate vegetative growth.

2. The soil material is so shallow that the rooting zone is not deep enough to support plants and furnish continuing supplies of moisture and plant foods.

3. The original soil to be vegetated contains material toxic to plant growth.

4. The soil is so acid that treatment with limestone is not feasible.

SPECIFICATIONS

SECTION I - SITE PREPARATION (Where Topsoil is to be Added)

A. When topsoiling, maintain needed erosion control practices such as diversions, grade stabilization structures, berms, dikes, level spreaders, waterways and sediment basins.

B. Grading: Grades on the areas to be topsoiled which have been previously established shall be maintained.

C. Liming: Where the subsoil is either highly acid or composed of heavy clays, ground limestone shall be spread at the rate of 100 pounds per 1,000 square feet. Lime shall be distributed uniformly over designated

areas and worked into the soil in conjunction with tillage operations as described in the following procedure.

D. Tilling: After the areas to be topsoiled have been brought to grade, and immediately prior to dumping and spreading the topsoil, the subgrade shall be loosened by discing or by scarifying to a depth of at least 2 inches to permit bonding of the topsoil to the subsoil. Pack by passing a bulldozer vertically tracking over the entire surface area of the slope to create horizontal erosion check slots to prevent topsoil from sliding down the slope.

SECTION II - TOPSOIL MATERIAL AND APPLICATION

Note: Topsoil salvaged from the existing site may often be used but it should meet the same standards as set forth in these specifications.

A. Materials: Topsoil shall be a loam, sandy loam, clay loam, silt loam, sandy clay loam or other soil as approved by an agronomist. It shall not have a mixture of subsoil and contain no slag, cinders, stones, lumps or soil, sticks, roots, trash or other extraneous materials larger than 1-1/2 inches in diameter. Topsoil must be free of plants or plant parts of bermudagrass, quackgrass, Johnsongrass, nutsedge, poison ivy, Canada thistle, or others as specified. All topsoil shall be tested by a recognized laboratory for organic content, pH and soluble salts. A pH of 6.0 to 7.5 and an organic content of not less than 1.5 percent by weight is required. If pH value is less than 6.0, lime shall be applied and incorporated with the topsoil to adjust the pH to 6.5 or higher. Topsoil containing soluble salts greater than 500 parts per million shall not be used.

No sod or seed shall be placed on soil which has been treated with soil sterilants until sufficient time has elapsed to permit dissipation of toxic materials.

Note: Topsoil substitutes or amendments as approved by a qualified Agronomist, may be used in lieu of natural topsoil.

B. Grading: The topsoil shall be uniformly distributed and shall be a minimum compacted depth of 2 inches on 3:1 or steeper slopes and 4 inches on flatter slopes. Spreading shall be performed in such a manner that sodding or seeding can proceed with a minimum of additional soil preparation and tillage. Any irregularities in the surface resulting from topsoiling or other operations shall be corrected in order to prevent the formation of depressions or water pockets. Topsoil shall not be placed while in a frozen or muddy condition, when the subgrade is excessively wet, or in a condition that may otherwise be detrimental to proper grading or proposed sodding.

Ammophila breviligulata Fernald, American beachgrass. An aggressive perennial with deep strong extensively creeping rhizomes. Culms (stems) grow in tufts commonly between 2 and 4 feet tall.

This plant is unexcelled for sand stilling and stabilization. It spreads rapidly through its underground stems (rhizomes) to form an erosion resistant cover. The foliage traps sand to build up the shoreline, yet as the sand deposits accumulate, this grass has the remarkable ability to grow up through over 2 feet of sand deposition during a single growing season and re-establish itself.

This plant is available from commercial producers and is shipped to users ready to plant. It can also be dug from native stands. Here again, be sure to secure young plants with vigorous root systems that are between 6 and 8 inches deep. 'Cape' variety is preferred.

Shake the sand from the roots and cut back tops so that the planting stock is approximately 15 inches long. Dip the plants in a clay slurry to coat roots to prevent desiccation. Bundle in moist burlap and keep cool until planted. Planting period - October 1 through April 30.

Planting. Separate the clumps so as to have 3 or more culms (stems) per plant. Plant in rows parallel to the shoreline with not over 2 feet spacing between plants and between rows. Use a staggered planting pattern. Planting depth should be between 8 and 10 inches (tiling spade best tool for hand planting).

Fertilize at time of planting with a controlled release fertilizer such as magnesium ammonium phosphate fertilizer (7-40-6). Place 1 to 1-1/2 oz. in bottom of each planting hole. Compact soil firmly aroung each plant.

VEGETATIVE ZONE 3

Particular attention should be given to the planting of the toe of the slope, if a graded slope, and to the area immediately above the bulkhead or slope revetment, if an along-shore structure is employed, as these areas are vulnerable to erosion. For this reason, it is best to establish a band of bermudagrass approximately 15 feet wide along these areas to provide maximum soil binding against erosion. The remainder of the upper slope may be planted to bermudagrass or tall fescue ('Ky-31').

Site Preparation

Grade as needed and feasible to permit the use of conventional equipment for soil preparation, sprigging or seeding (slope not to exceed 3 feet horizontal) to 1 foot vertical). Save topsoil for use on drastically disturbed slopes. Remove trees from top of slope and on slope to prevent windthrow damage and shading of grasses. Intercept over-bank flow of surface water and divert down through structures. If there is seepage on face of slope, bench slope and drain with tile as needed and feasible.

Soil Preparation

If soils are reasonably uniform, lime and fertilize according to soil test. In absence of soil test, apply 2,000 pounds of pulverized dolomitic limestone and 1,000 pounds of granulated 10-10-10 fertilizer, or its equivalent per acre. Harrow or disc lime and fertilizer into the soil to a depth of 3 to 4 inches. Make sure last tillage operation is on the contour.

Plant Materials: All species listed below are adapted - droughty sands to heavy impervious clay materials.

Cynodon dactylon, (L.) Pers., ('Tufcote' bermudagrass)
A long-lived, low-growing perennial that forms a dense sod which is both drought and salt tolerant. Bermudagrass, being a warm season grass, grows during the hot summer months and is dormant during the winter. It thrives on close mowing. Planting stock is available commercially.

Cynodon Dactylon, (L.) Pers., ('Midland' bermudagrass)
This grass is available commercially and may be substituted for 'Tufcote'. It is taller growing, more haylike, and does not form as dense a turf as that formed by 'Tufcote'.

PLANTING

Bermudagrass is established by planting sprigs (small section of plant 3 to 4 inches long with at least one node or joint with leaves) by hand or with a transplanter in a firm moist seedbed to a depth of 2 to 3 inches.

Compaction of soil around the sprig is a must for survival. Planting period - April 15 to August 15. Recommended spacing - 18 inches x 18 inches. (This will require approximately 40 bu. of sprigs per acre. One square yard of sod or bushel of bermudagrass sprigs will yield approximately 500 plantable pieces.)

Good soil moisture must be maintained the first two weeks following planting, thus supplemental irrigation may be necessary.

MAINTENANCE

To maintain a vigorous, weed-free cover, annual applications of nitrogen during the warm months are important. Depending upon the soil type, exposure and usage, the total amount of nitrogen may vary from 50-200 pounds per acre per year. A complete fertilizer such as 5-10-10 (500 pounds per acre) should be applied during August or September to harden off bermudagrass for winter on medium to heavy texture soils.

Festuca arundinacea, Schreb. 'Ky-31' tall fescue.
A cool season, salt tolerant, grass which forms a heavy turf and persists longer on the heavier textured soils. 'Ky-31' tall fescue seed is available commercially.

References

1. Guideline Specifications, Soil Preparation and Sodding. MD-VA, Pub. #1, Cooperative Extension Service, University of Maryland-Virginia Polytechnic Institute. Revised 1973.

Maryland Forest Service
Annapolis, Maryland

STANDARD AND SPECIFICATIONS

FOR

PROTECTION OF TREES IN URBANIZING AREAS

Definition

Protection of desirable trees from mechanical and other injury while the land is being converted from agricultural to urban use.

Purpose

To employ the necessary protective measures to insure the survival of desirable trees for shade, beautification and vegetative cover.

Conditions Where Practice Applies

On areas now occupied by single specimen trees or groups of trees.

A. Criteria for deciding upon the trees to leave:

1. Esthetic values: Consideration should be given to autumn foliage, flowering habits, bark and crown characteristics, and type of fruit.

2. Freedom from disease and rot.

3. Life span of trees: Some are considered short-lived trees.

4. Wind firmness: Virginia pine has a very shallow root system, and trees will blow over easily if they have been growing in a close stand.

5. Wildlife values: Oaks, hickories and dogwoods, etc. have a high food value.

6. Comfort index: Summer temperatures are generally ten degrees cooler under stands of hardwoods than pines or cedars.

7. Sudden exposure: to direct sunlight and ability to withstand radiated heat from proposed building and pavement.

8. Space needed: for future growth and relationship to structures, electric and telephone lines, water and sewer lines and driveways. Mark trees with bright paint or ribbon so there is no doubt as to which trees are to be left and protected from damage during construction.

B. Criteria for protecting remaining trees:

1. Where existing ground levels are raised, drainage tiles will be placed at the old soil level and open into a well built around the base of the tree. This well can be left open or can be filled with coarse stones or gravel. Tiles may be installed in a radiating pattern or laid in parallel lines. The size of the well should be in proportion to diameter of tree and diameter of the radiating tiles. (Fig. 1)

2. Trees within 25 feet of a building site shall be boxed in to prevent mechanical injury. (Fig. 2)

3. Boards will not be nailed to trees during building operations. (Fig. 2)

4. Heavy equipment operators will be cautioned to avoid damage to existing tree trunks and roots during land leveling operations. Tunnel under root system when installing utility lines, if possible.

5. Tree trunks and exposed roots and limbs damaged during equipment operations, will be cared for as prescribed by a forester or licensed tree expert. (Fig. 1 & 2)

6. Wood chips when spread to a 6 inch depth can be used in wooded sites to help prevent soil compaction and damage to trees.

7. The use of heavy equipment on root systems of desirable trees should be avoided as much as possible to minimize soil compaction. All construction should be kept out of the drip line of protected trees.

8. Broad leaf trees should receive a heavy application of complete fertilizer to aid their recovery from possible damage caused by construction operations. Fertilization should be done during winter and/or early spring following completion of construction. It should be applied at the following rate: 2 to 4 lbs. of 10-6-4 for each diameter inch of trunk measured at 4-1/2 feet above ground line. Fertilizer should be applied in holes 1" in diameter 18" deep. Spaced about 2' apart at the drip line of the tree.

9. During the first two summers following construction, it is desirable that the trees receive adequate amounts of water. Do not overwater.

References

1. Maryland Water Resources Administration Audiovisual Training Program, "Wooded Site Development."

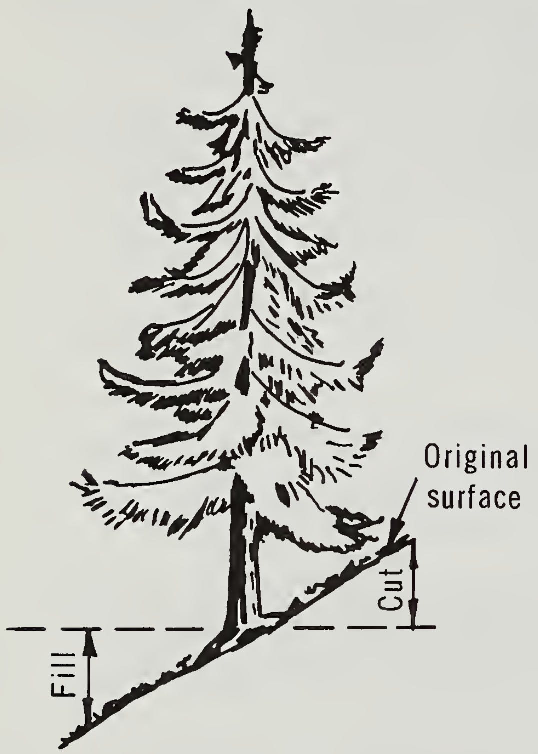
2. Agricultural Information Bulletin 285, "Protecting Trees Against Damage from Construction Work", Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402 - 15¢ a copy.

3. Guidelines for the Control of Erosion and Sediment in Urban Areas of the Northeast, USDA, Soil Conservation Service, Upper Darby, Pa., 1970.

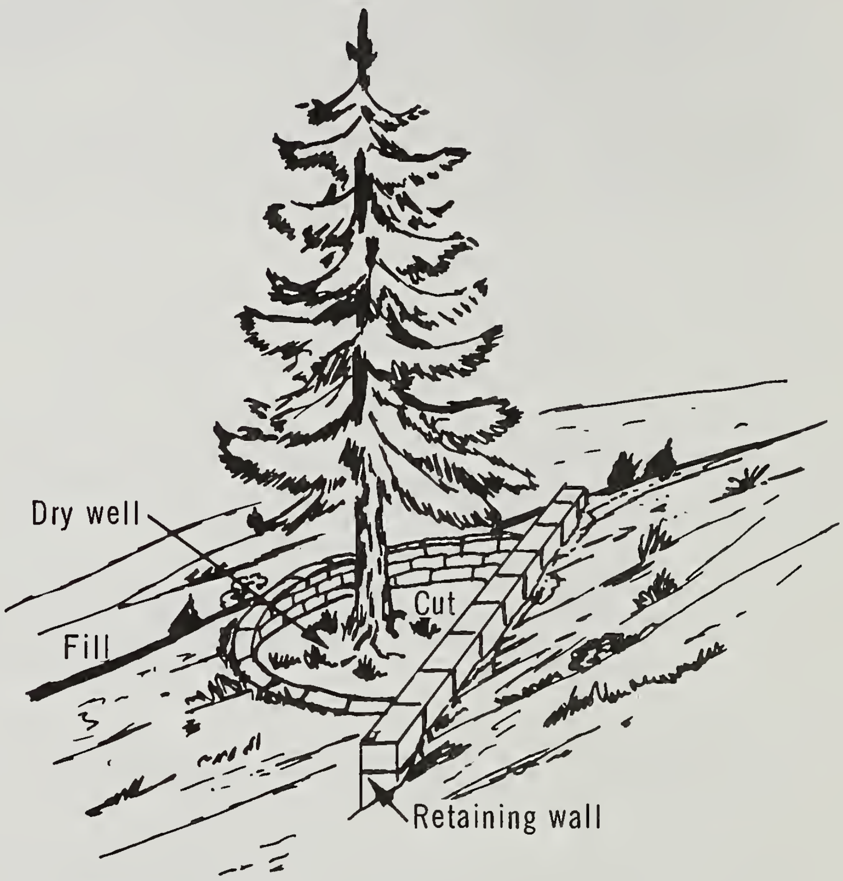
CUTS AND FILLS

Excessive cuts or fills can kill a tree in a few weeks by destroying shallow feeder roots. Fertilizing, frequent watering and tree crown removal could be required to compensate for any damage to root system.

NO

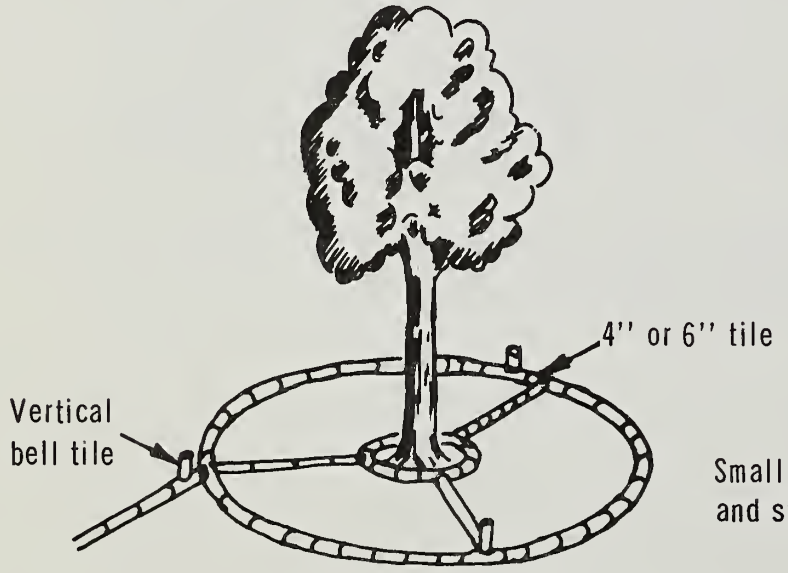


YES



HANDLING EXCESSIVE FILL

Minor fills to 6 or 8 inches composed of noncompacted loamy topsoil material high in organic matter usually do not harm trees. Major fills will require drain tile on top of original surface and other treatment.



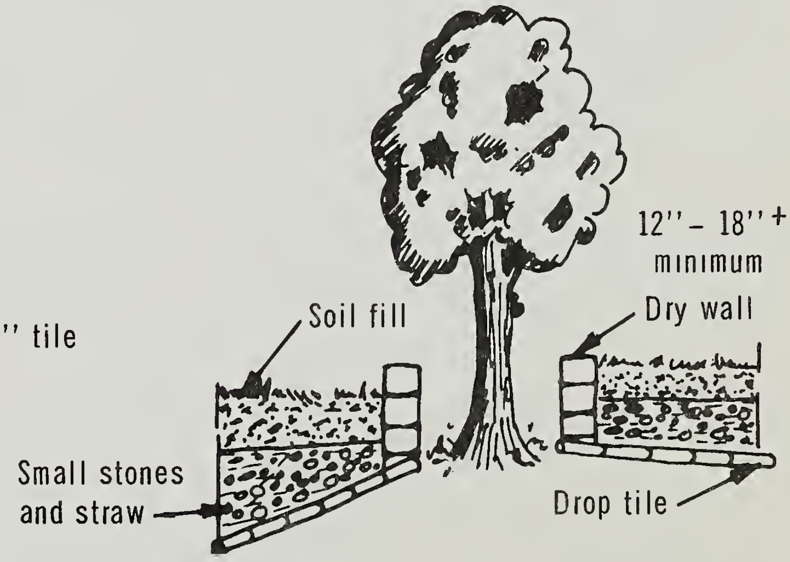
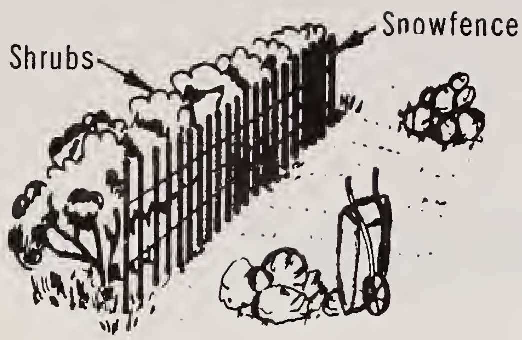
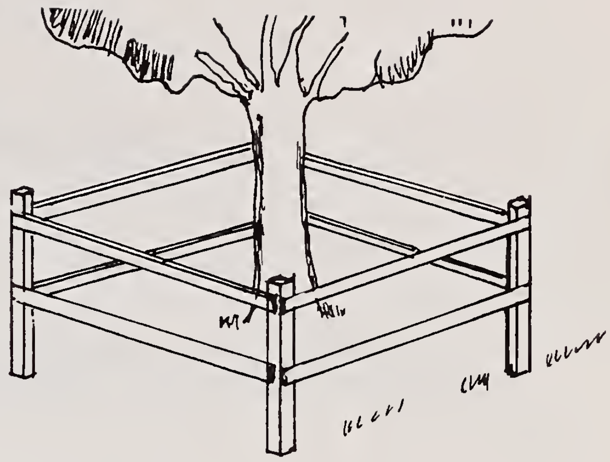


Figure 1

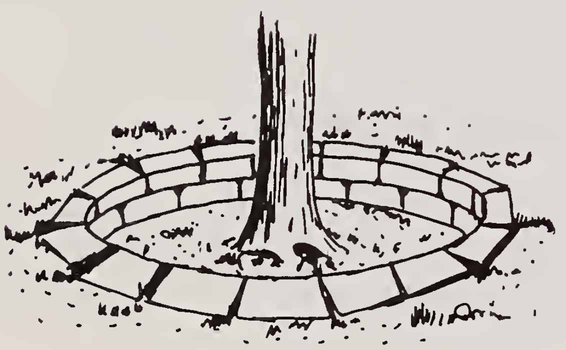
METHODS OF PROTECTION



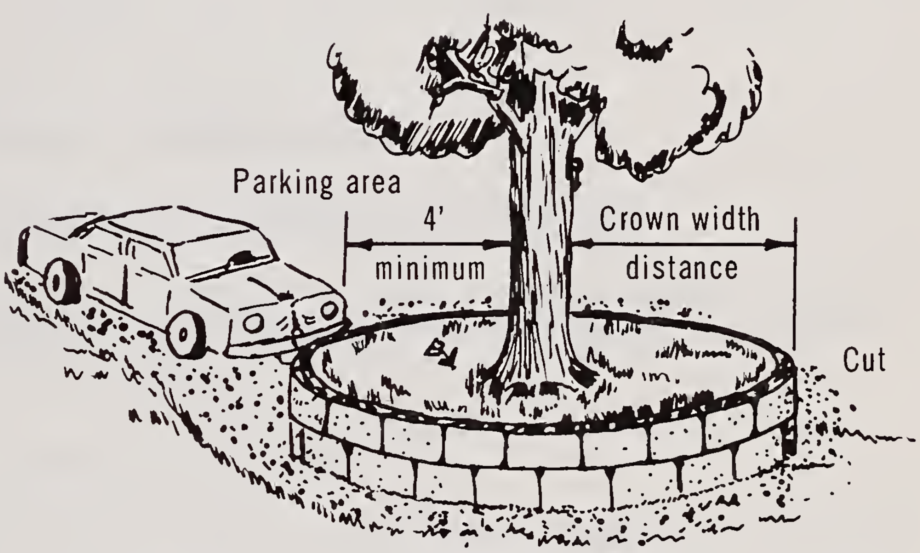


FENCE

Temporary



TREE WELL



RETAINING WALL

Permanent

WOODED AREAS

In densely wooded areas, tree removal should be done by experienced personnel to avoid damaging trees to be kept.

Figure 2

STANDARD AND SPECIFICATIONS FOR CRITICAL AREA PLANTING (Stripmine Areas in Western Maryland)

Definition

Planting vegetation such as trees, shrubs, vines, grasses, or legumes on critical areas. (Does not include tree planting mainly for wood products.)

Purpose

To stabilize the soil; reduce damage from sediment and runoff to downstream area; improve wildlife habitat, and enhance natural beauty.

Where Applicable

On sediment-producing, highly erodible or severely eroded areas, such as mine spoil, surface-mined areas, and denuded areas where vegetation is difficult to establish with usual seeding or planting methods.

Planning considerations

Permanent Erosion Control Structures and Measures

Permanent erosion control structures and measures are to be installed as per the approved erosion control schedule submitted to the Department of Water Resources or other responsible county agency.

Types of Seedings

Temporary seedings or mulching shall be made on all areas subject to erosion which may contribute sediment to nearby streams for any duration up to a year where final grade requirements cannot be met at time of seeding. Similar areas subject to erosion for more than one year shall be seeded to a permanent seeding mixture.

Permanent seedings shall be made on all areas where final grade requirements have been met.

SPECIFICATION FOR TEMPORARY SEEDINGS

Site Preparation

A. Install needed erosion control practices as required by the approved erosion control schedule. These practices may include but are not limited to, diversions, grade stabilization structures, berms, dikes, level spreaders and sodded waterways, and sediment basins.

B. Final grading and shaping shall not be required for temporary seedings.

Soil Amendments

For temporary seedings, fertilizer shall be applied at the rate of 400 lbs/ac. or 10 lbs/1000 sq. ft., using 10-20-20 or equivalent. Soils which are known to be highly acid should be limed.

Seedbed Preparation

When the area to be seeded has been recently loosened to the extent that an adequate seedbed exists, no additional treatment is required. When the area to be seeded is packed, crusted, and hard, the top layer of soil shall be loosened by raking, discing, or other acceptable means before seeding. No mechanical preparation is needed where seeding will be done within 30 days after spoil placement or during early spring freeze-thaw period.

Seeding Mixtures and Planting Season

A. Select one of the following species:

Grass	Amount	Above 1800' Elevation	Below 1800' Elev.
1. Italian ryegrass	40 lbs/ac.	Mar. 15 - Sept. 1	Mar. 15 - June 1 and Aug. 1 - Aug.15
2. Oats	3 bu/ac.	Mar. 15 - Sept. 1	Mar. 15 - June 1
3. Rye	2-1/2 bu/ac.	Mar. 15 - Oct. 1	Marl 15 - June 1 and Aug. 1 - Oct.31
4. Weeping lovegrass	3 lbs/ac.	---	May 1 - July 15

B. Apply seed uniformly with a cyclone seeder, drill, cultipacker or hydroseeder (slurry includes seed and fertilizer).

SPECIFICATION FOR PERMANENT SEEDINGS

Site Preparation

A. Install needed erosion control practices as required by the approved erosion control schedule. These practices may include, but are not limited to interceptor ditches, diversions, berms and terraces, contour ripping, erosion stops, channel liners and desilting basins.

B. Grade as needed and feasible to permit the use of conventional equipment for seedbed preparation, seeding, mulch application, anchoring and maintenance.

Seedbed Preparation

All areas shall be loose and friable to a depth of at least 3 inches. When the area to be seeded has been recently loosened to the extent that an adequate seedbed exists, no additional treatment is required. However, when the area to be seeded is packed, crusted, and/or hard, the top layer of soil shall be loosened by scarifying, discing or other acceptable means before seeding.

Soil Amendments

Lime and fertilize, preferably according to soil tests. Lime and fertilizer needs can be determined by a soil testing laboratory, such as the University of Maryland's Soil Testing Laboratory.

In lieu of soil test results, apply 3 tons/ac. of ground agricultural limestone and 1,000 pounds per acre of 10-10-10 fertilizer or equivalent before or at time of, seeding. Harrow or disc lime and fertilizer uniformly into the soil to a minimum depth of 3 inches, except when seeded by hydroseeder. The final harrowing or discing operation should be on the approximate contour. No attempt should be made to drag or otherwise smooth the soil surface. Top-dress the following year with 500 pounds per acre of 10-10-10, or equivalent, fertilizer unless excepted by the responsible agency.

Seeding Mixtures and Planting Seasons

A. Select one of the following mixtures:

Species	Rate Lbs/Ac.	Seeding dates (d) Below 1800' Elev.
1. Birdsfoot trefoil, 'Viking' (a) (triple inoculated)	10	Mar. 5 - Jan. 1 &
'Kentucky 31' tall fescue	50	Aug. 1 - Oct. 1
Canada bluegrass (b)	10	
2. Crownvetch (c) (triple inoculated)	10	Mar. 5 - June 1 &
'Kentucky 31' tall fescue	50	Aug. 1 - Oct. 1

Species	Rate Lbs/Ac.	Seeding dates (d) Below 1800' Elev.
3. Birdsfoot trefoil (a) (triple inoculated)	10	Jun. 1 - Aug. 1
Weeping lovegrass	3	
4. Crownvetch (c) (triple inoculated)	15	Jun. 1 - Aug. 1
Weeping lovegrass	3	
5. Weeping lovegrass (e)	3	Jun. 1 - Aug. 1
6. Redtop (e)	5	Mar. 5 - Jun. 1 & Aug. 1 - Oct. 1

Mixture Footnotes

(a) Birdsfoot trefoil tolerates lower pH and wetter soil conditions than crownvetch.
(b) Add the Canada bluegrass for late fall seedings.
(c) Use crownvetch on all slopes which exceed 2:1 in steepness.
(d) Above 1800' elevation, seeding dates are from March 15 to August 15.
(e) Add bristly locust, black locust, autumn olive or Russian olive to mixture at the rate of 1 to 2 pounds per acre.

B. Apply seed uniformly on seedbed with a cyclone seeder, drill, cultipacker seeder or hydroseeder (slurry may include seed and fertilizer) on a firm, moist seedbed. Maximum seeding depths should be to 1/2 inch on heavy soils and 1 inch on light soils, when using other than hydroseeder method of application.

Mulching

A. Materials and Amounts

1. Straw - Straw shall be unrotted small grain straw applied at the rate of 1-1/2 to 2 tons per acre, or 70 to 90 pounds per 1,000 sq. ft. Mulch materials shall be relatively free of all kinds of weeds and shall be free of prohibited noxious weeds which are: Canada thistle, Johnsongrass and quackgrass.

   Spread uniformly by hand or mechanically. For uniform distribution of hand spread mulch, divide area into approximately 1,000 sq. ft. section and place 70-90 lbs. of mulch in each section.

2. A fast-growing crop of small grain rye or spring oats may be chemically killed in place to serve as a mulch for seeding permanent species suitable for long term protective cover.

3. Mulch nettings such as jute or excelsior blanket may be used. Staple to surface in waterways and on steep slopes. Lighter materials of paper, plastic and cotton mulch nettings may be used where erosion hazard is not severe. If area is to be mowed, do not use metal staples.

4. Wood chips at the rate of approximately 6 tons per acre may be used when available and when feasible to use.

5. Other organic material approved by the Land Reclamation Committee and/or responsible agency.

B. Mulch anchoring shall be accomplished immediately after mulch placement to minimize loss by wind or water. This may be done by one of the following methods, depending upon size of area, erosion hazard, and cost. On sloping land, practice No. 3 below, should be done on the contour wherever possible. Applies to straw and to wood chips on more critical sites.

1. Peg and Twine - Drive 8 to 10-inch wooden pegs to within 2 to 3 inches of the soil surface every 4 feet in all directions. Stakes may be driven before or after applying mulch. Secure mulch to soil surface by stretching twine between pegs in a criss-cross within a square pattern. Secure twine around each peg with two or more round turns.

2. Mulch Nettings - Staple lightweight biodegradable paper, plastic or cotton nettings over the mulch according to manufacturer's recommendations. Netting is usually available in rolls 4 feet wide and up to 300 feet long.

3. Mulch Anchoring Tool - A tractor drawn implement designed to punch and anchor mulch into the surface 2 inches of soil. This practice affords maximum erosion control but is limited to flatter slopes where equipment can operate safely.

4. Liquid Mulch Binders
Applications of liquid binders should be heavier at edges where wind catches mulch, in valley, and at crest of banks. Remainder of area should be uniform in appearance. Caution should be used with asphalt in residential and similar areas.

   a. Cutback asphalt - rapid curing (RC-70, RC-250, and RC-800) or medium curing (MC-250 or MC-800). Apply 5 gallons per 1,000 sq. ft. or 200 gallons per acre on flat areas, and on slopes less than 8 feet high. On slopes 8 feet or more high, use 8 gallons per 1,000 sq. ft. or 348 gallons per acre.

b. Emulsified asphalt - (SS-1, CSS-1, CMS-2, MS-2, RS-1, RS-2, CRS-1, and CRS-2). Apply 5 gallons per 1,000 sq. ft. or 200 gallons per acre on flat areas and on slopes less than 8 feet high. On slopes 8 feet or more high, use 8 gallons per 1,000 sq. ft. or 348 gallons per acre.

All asphalt designations are from the Asphalt Institute Specifications.

c. Synthetic binders - Synthetic binders such as Curasol, DCA-70. Petroset and Terra Tack may be used at rates recommended by the manufacturer or responsible agency to anchor mulch material.

Note: All names given above are registered trade names. This does not constitute a recommendation of these products to the exclusion of other products.

Synthetic binders must be acceptable to the responsible agency or Land Reclamation Committee.

References

1. Evaluation of Woody Plants and Development of Establishment Prodedures for Direct Seeding and/or Vegetative Reproduction, AW 73-75-46 for State Highway Administration by USDA, Soil Conservation Service.

2. USDA, Soil Conservation Service Field Office Technical Guides.

3. A Two-Step System for Revegetation of Surface Mine Spoils. J. N. Jones, W. H. Armiger, and O. L. Bennett, Journal of Environmental Quality, Vol. 4, No. 2, 1975, pages 233-235.

STANDARD AND SPECIFICATIONS FOR DUNE STABILIZATION

Definition

Controlling surface movement of sand dunes or shifting sand by vegetative means.

Purpose

To stabilize frontal dunes and reduce soil blowing and the encroachment of shifting sands on valuable property; provide a barrier against tide water; and to make the areas useful for other purposes.

Conditions Where Practice Applies

On seashore areas where blowing sands, tide and storm water may cause damage.

Site Conditions

Land adjoining the Atlantic Ocean is usually sandy in nature and is composed of a line of primary dunes which are discontinuous in nature. These dunes are naturally rather bare on the ocean side making them vulnerable to wind and water action. Without man's help, the primary dunes are not a dependable protective barrier to protect the secondary area. This was not a serious problem until man started developing these areas for habitation, for recreational and other facilities. In many cases, man has been his own enemy by flattening dunes to make construction work easier. Automobiles, dune buggies and foot traffic have all damaged natural dunes making it difficult to maintain continuous, elevated dunes.

Man's constructive activities in dune building and stabilization consist of building dunes to an elevation of 16 feet and the crown 25 feet wide, with side slopes of 5:1. This is accomplished by erecting stilling barriers of slat (snow) fences and planting of vegetation at desired locations to catch sand and help keep it in place. Tests have proved American beachgrass to be the only reliable grass to plant for primary dune stabilization. In some cases, it is best to start a dune where none exists by erecting a small dike which can then be given adequate height and cross-section by the above-mentioned techniques. Planting is delayed on hydraulic fill until salt has been leached to a low level. Sand placed by earth-moving equipment is allowed to be compacted by rains prior to dune planting. Dunes built with the aid of mechanical barriers are planted when the dune is near top of fences and elevation is near desired height.

SPECIFICATIONS

A. Building Dunes by Mechanical Methods

1. In frontal areas, dunes may be created by erection of snow fences, brush fences, or Christmas trees set in parallel rows 20 to 30 feet apart, parallel to the beach, and well back from the mean high water line. Barriers are added until the desired height and width of the dune is obtained. The frontal dune should be about 120 feet wide at the base and 16 feet high; the crown should be approximately 25 feet across.

   a. If brush is used, it is lashed to horizontal rails nailed to a line of posts.

   b. If Christmas trees are used, they are anchored well in the sand spaced to touch each other in the row.

2. Dunes are stabilized as in B, below with American beachgrass.

3. Where foot or vehicular traffic is appreciable over frontal dunes, it is advisable to direct the traffic over clay-base foot paths or removable walks to prevent dune blow-out.

B. Vegetative

1. Ammophila breviligulata Frenald, American beachgrass, which can be bought from commercial nurseries is best planted between October 1 and April 30 when sand is not frozen. Planting can be done by hand or by mechanical planters. 'Cape' variety is preferred.

2. Three to five culms (stems) with roots, which may be joined are placed in a hole approximately 8 to 9 inches deep.

3. It is recommended that planting stock be cut back to approximately 15 inches high. Roots should be dipped in a mud slurry to prevent them from drying during planting.

4. Plants are spaced 18" x 18" (19,360 plants/Ac;) except where erosion is severe, the spacing should be 12" x 12" (43,560 plants/Ac). Plants should be staggered in alternate rows.

5. A common grade of mineral fertilizer equivalent to 600 lbs. per acre of 10-10-10 or a slow-release fertilizer such as 7-40-6 (Magnesium Ammonium phosphate) is applied at the rate of 1 oz. per hill. Mineral fertilizer, when used, is applied as a topdressing. When a slow-release fertilizer is used, it is placed in the holes with plants being planted. The slow-release fertilizer will usually be adequate to maintain fertility for 3 growing seasons.

6. The sand is packed firmly around the roots to eliminate air pockets.

7. When plants are used to build dunes, the plantings should consist of at least 10 rows paralleling the shoreline to trap the sand and form a continuous band. Rows should be closer together at the center of the dune and wider apart at the edges. Dunes enlarge faster when mechanical and vegetative methods are both used.

8. Protect the vegetated area from traffic.

9. Maintenance - Fertilizer should be added when plant vigor starts declining after establishment. Apply a complete granular fertilizer such as 10-10-10 at rate of 400 pounds per acre in April or May and again in July.

   Areas that are damaged or fail to take should receive immediate remedial action.

References:

1. Response of American Beachgrass to Fertilizer, by Marshall T. Augustine, Robert B. Thornton, James M. Sanborn and Andrew T. Leiser. Journal of Soil and Water Conservation, May - June 1964.

2. Development and Use of American Beachgrass for Dune Stabilization, by Robert B. Thornton and Arnold G. Davis, Presented at American Society of Agronomy Meeting, Kansas City, Mo., November 1964.

3. How to Build and Save Beaches and Dunes by John A. Jagschitz and Robert C. Wakefield, University of Rhode Island. Marine Leaflet Series No. 4.

4. Restoration and Retention of Coastal Dunes with Fences and Vegetation, by J. A. Jagschitz and R. S. Bell. Bulletin 382, January 1966. Agricultural Experiment Station, University of Rhode Island, Kingston, R. I.

STANDARDS AND SPECIFICATIONS FOR TOXIC SALT REDUCTION

Definition

Reducing or redistributing the harmful concentrations of salt in the soil.

Purpose

To reduce harmful amounts of salt to permit use of vegetative cover.

Where Applicable

On dredged soils or hydraulic fills where the accumulation of salt at or near the surface limits the growth of desirable plants.

Site Conditions

Land bordering on Chesapeake Bay and the Atlantic Ocean is occasionally flooded by salt water. Many soils develop saline subsoils, and to a lesser extent, salty surface conditions. The soil salinity has frequently been great enough to damage existing crops or other plants. In natural conditions, salt tolerant species such as *Spartina patens* (Ait.) Muhl., Saltmeadow cordgrass; *Distichlis spicata* (L.) Greene, Seashore saltgrass; and *Spartina alternaflora* Loisel., smooth cordgrass, occupy these soils. However, dredging and earth-moving in these saline sites destroy adapted cover and bring harmful amounts of salt to the surface. Plants do not usually thrive on these salty conditions until the salinity, and sometimes high sodium content, are lowered by leaching.

SPECIFICATIONS

1. Soil Test. Have a soil test made to determine the amount of salt present. Obtain representative sample from the top 3 inches of soil and another sample to represent the 3 to 6 inch depth. County agents can assist with soil sample boxes and further instructions on how to take soil sample. Assistance is also available from your Soil Conservation District office.

2. Salt Tolerance of Plants. Plants vary widely in their tolerance to salt in the soils. For example, barley can tolerate approximately 2,000 parts per million (ppm) of salt while red clover is very sensitive and can tolerate only about 300 ppm. See Table 61-1 for the salt tolerance of other plants. Transplanting adapted native grasses on the site may be necessary, if soil is severely salty.

3. Use of Gypsum and Superphosphate. In cases where the soil contains more salt than the crop to be grown can tolerate and it is necessary to bring the land back into production as soon as possible, gypsum can be used to help remove the excess salts from the soil. The calcium will replace the sodium from the clay particles. Once in solution, the sodium salts can be removed by leaching. Test the soil to determine if lime is needed for the crop to be grown. In cases where lime is required, 1/2 should be plowed under and the remainder should be applied and disced into the soil.

   a. Gypsum. Calcium sulfate (gypsum) is more soluble than limestone and will react somewhat faster in the soil to remove the excess salts. This material should be used where fast reaction is desired to remove the salts. If you decided to use gypsum, apply it after plowing and mix thoroughly into the soil by discing and harrowing. See Table 61-2 for amounts of gypsum to use for removing excess salts from soils.

TABLE 61-1

Relative Tolerance of Crop to Salt in Soil

Salt Tolerance Level 1/	Plants	
	Temporary	Permanent
Very high (Approx. 2,000 ppm)	Barley Sweet clover	Bermudagrass Perennial ryegrass
High (Approx. 1,500 ppm)	Rye Wheat Oats	Tall fescue
Medium (Approx. 1,000 ppm)		Orchardgrass Reed canarygrass
Low - less than 1,000 ppm)		Red clover Ladino clover

1/ This level of salt is based upon a sandy loam soil. The crops near the top of the column within a given group are more tolerant than those at the bottom.

TABLE 61-2

Recommended Amounts of Gypsum for Removing
Excess Salts from Soil-Pounds Per Acre

Soil Type	Gypsum
Loamy Sand	1,500
Sandy Loam	2,000
Loam	2,500
Silt Loam	3,500

b. Superphosphate. In addition to phosphorous, superphosphate contains about 50% calcium sulfate (gypsum). On soils that are low in phosphorus, 500 to 1,000 lbs. per acre of superphosphate will help to build up the phosphorous level of the soil and at the same time will supply gypsum which will help to remove the excess salts. The amount of gypsum supplied by the superphosphate can be subtracted from the amount recommended in Table 61-2.

4. Use of Mulches. There is only one practical way to remove salts from the soil; that is by leaching downward to reduce salinity in rooting zones to levels which can be tolerated by the plant species being grown. Adding animal manures with straw or other organic bedding or straw alone are methods of soil treatment which speed up downward movement of the soluble salts. Well-decomposed feedlot manure or chicken house litter can be utilized up to 10-20 tons per acre for this purpose.

   Where small grain straw is used, 2 to 3 tons per acre is plenty to provide a complete surface mulch. A high or a seasonally-high water table will tend to prevent proper leaching of salts. Therefore, good drainage is desirable.

   Anchor mulch, on areas where wind or water are likely to remove it, by one of the following methods:

   1. Peg and Twine - Drive 8- to 10-inch wooden pegs to within 2 to 3 inches of the soil surface every 4 feet in all directions. Stakes may be driven before or after applying mulch. Secure mulch to soil surface by stretching twine between pegs in a criss-cross within a square pattern. Secure twine around each peg with two or more round turns.

   2. Mulch Nettings - Staple lightweight biodegradable paper, plastic, or cotton netting over the mulch according to manufacturer's recommendations. Netting is usually available in rolls 4 feet wide and up to 300 feet long.

3. Mulch Anchoring Tool - (Not a farm disc) A tractor drawn implement designed to punch and anchor mulch into the surface 2 inches of soil. This practice affords maximum erosion control, but its use is limited to slopes upon which the equipment can operate safely. Tracking - primarily used on steeper cut and fill slopes to cut the mulch into the soil with cleated bulldozer tracks.

4. Liquid Mulch Binders - Use one of the following:

   Applications of liquid binders should be heavier at edges where wind catches mulch, in valleys, and at crests of banks. Remainder of area should be uniform in appearance. Caution should be used with asphalt in residential and similar areas.

   a. Cutback asphalt - rapid curing (RC-70, RC-250 and RC-800) or medium curing (MC-250 or MC-800). Apply 5 gallons per 1,000 sq. ft. or 200 gallons per acre on flat areas, and on slopes less than 8 feet high. On slopes 8 feet or more high, use 8 gallons per 1,000 sq. ft. or 348 gallons per acre.

   b. Emulsified asphalt - (SS-1, CSS-1, CMS-2, MS-2, RS-1, RS-2, CRS-1, and CRS-2). Apply 5 gallons per 1,000 sq. ft. or 200 gallons per acre on flat areas and on slopes less than 8 feet high. On slopes 8 ft. or more high, use 8 gallons per 1,000 square feet or 348 gallons per acre.

      All asphalt designations are from the Asphalt Institute Specifications.

   c. Synthetic binders - Synthetic binders such as Curasol, DCA-70. Petroset and Terra Tack may be used at rates recommended by the manufacturer to anchor mulch material.

      Note: All names given above are registered trade names. This does not constitute a recommendation of these products to the exclusion of other products.

References:

1. Agriculture Handbook No. 60, "Diagnosis and Improvement of Saline and Alkali Soils", by United States Salinity Laboratory Staff.

2. University of Maryland, Agronomy Department, Agronomy Mimeo No. 8 Rev., May 1962, "How to Treat Salt Damaged Land."

STANDARD AND SPECIFICATIONS

FOR

DUST CONTROL

Definition

Controlling dust blowing and movement on construction sites and roads.

Purpose

To prevent blowing and movement of dust from exposed soil surfaces, reduce on and off-site damage, health hazards and improve traffic safety.

Conditions Where Practice Applies

This practice is applicable to areas subject to dust blowing and movement where on and off-site damage is likely without treatment.

SPECIFICATIONS

TEMPORARY METHODS:

A. Mulches - See standards for critical area stabilization with mulches only. Chemical mulch binders may be used instead of asphalt to bind mulch material. Binders such as Curasol or Terratack should be used according to manufacturer's recommendations.

B. Vegetative Cover - See standards for temporary vegetative cover.

C. Spray-on Adhesives - On mineral soils (not effective on muck soils). Keep traffic off these areas.

	Water Dilution	Type of Nozzle	Apply-Gallons/Ac.
Anionic asphalt emulsion	7:1	Coarse Spray	1,200
Latex emulsion	121/2:1	Fine Spray	235
Resin-in-water emulsion	4:1	Fine Spray	300

D. Tillage - to roughen surface and bring clods to the surface. This is an emergency measure which should be used before soil blowing starts. Begin plowing on windward side of site. Chisel-type plows spaced about 12" apart, spring-toothed harrows, and similar plows are examples of equipment which may produce the desired effect.

E. Irrigation - This is generally done as an emergency treatment. Site is sprinkled with water until the surface is moist. Repeat as needed.

F. Barriers - Solid board fences, snow fences, burlap fences, crate walls, bales of hay and similar material can be used to control air currents and soil blowing. Barriers placed at right angles to prevailing currents at intervals of about 15 times their height are effective in controlling soil blowing.

G. Calcium Cloride - Apply at rate that will keep surface moist. May need retreatment.

PERMANENT METHODS:

A. Permanent Vegetation - See standards for permanent vegetative cover, and permanent stabilization with sod. Existing trees or large shrubs may afford valuable protection if left in place.

B. Topsoiling - covering with less erosive soil material. See standards for topsoiling.

C. Stone - cover surface with crushed stone or coarse gravel.

REFERENCES:

Agriculture Handbook 346
Wind Erosion Forces in the United States and their Use in Predicting Soil Loss.

Agriculture Information Bulletin 354.
How to Control Wind Erosion USDA-ARS.

STANDARD AND SPECIFICATIONS FOR PROTECTIVE MATERIALS FOR CHANNELS AND STEEP SLOPES

Definition

Installing jute or excelsior mattings on a prepared seed - or planting - bed of a channel or steep slope to be stabilized with vegetation.

Purpose

As an aid to controlling erosion on critical sites during establishment period of protective vegetation.

Conditions Where Practice Applies

In channels where designed flow exceeds 3.5 feet per second; on short, steep slopes where erosion hazard is high and planting is likely to be slow to establish adequate protective cover; on tidal - or stream - banks where moving water is likely to wash out new vegetative plantings.

MATERIALS

A. Jute mat shall be cloth of a uniform plain weave of undyed and unbleached single jute yarn, 48 inches in width plus or minus 1 inch and weighing an average of 1.2 pounds per linear yard of cloth with a tolerance of plus or minus 5 percent, with approximately 78 warp ends per width of cloth and 41 weft ends per linear yard of cloth. The yarn shall be of a loosely twisted construction having an average twist of not less than 1.6 turns per inch and shall not vary in thickness by more than one half its normal diameter.

B. Excelsior mat shall be wood excelsior, 48 inches in width plus or minus 1 inch and weighing 0.8 pounds per square yard plus or minus 10 percent. The excelsoir material shall be covered with a netting to facilitate handling and to increase strength.

C. Glass fiber matting of bonded textile glass fibers with an average fiber diameter of 8 to 12 microns, 2 to 4 inch strands of fiber bonded with phenol formaldehyde resin. Mat shall be roll type, water permeable, minimum thickness 1/4 inch, maximum thickness 1/2 inch, density not less than 3 pounds per cubic foot.

D. Staples - staples for anchoring soil stabilizing materials shall be no. 11 gauge wire or heavier. Their length shall be 6 to 10 inches, with the longer staples used on loose, unstable soils.

INSTALLATION REQUIREMENTS

Site Preparation: After site has been shaped and graded to approved design, prepare a friable seedbed relatively free from clods and rocks more than 1-1/2 inches in diameter, and any foreign material that will prevent contact of the protective mat with the soil surface.

Planting: Lime, fertilize, and seed in accordance with seeding or other type of planting plan, except when using jute matting on a seeded area, apply approximately one-half the seed after laying the mat. The protective matting can be laid over sprigged areas where small grass plants have been planted. Where ground covers are to be planted, lay the protective matting first and then plant through the matting according to design of planting.

Erosion Stops: (For use on steep, highly erodible watercourses) Erosion stops are made of glass fiber strips, excelsior matting strips or tight-folded jute matting blanket or strips. They are placed in narrow trenches 6 to 12 inches deep across the channel and left flush with the soil surface. They are to cover the full cross-section of designed flow.

How Used: Under jute or excelsior matting.

Location:

1. Approximately 3 feet down channel from point of entry of a concentrated flow such as from culverts, tributary channels or diversions.
2. At points where change in gradient or course of channel occurs.
3. Spacing of erosion stops on long slopes will vary from 20 to 100 feet depending upon the erodibility of the soil and velocity and volume of flow.

Installation:

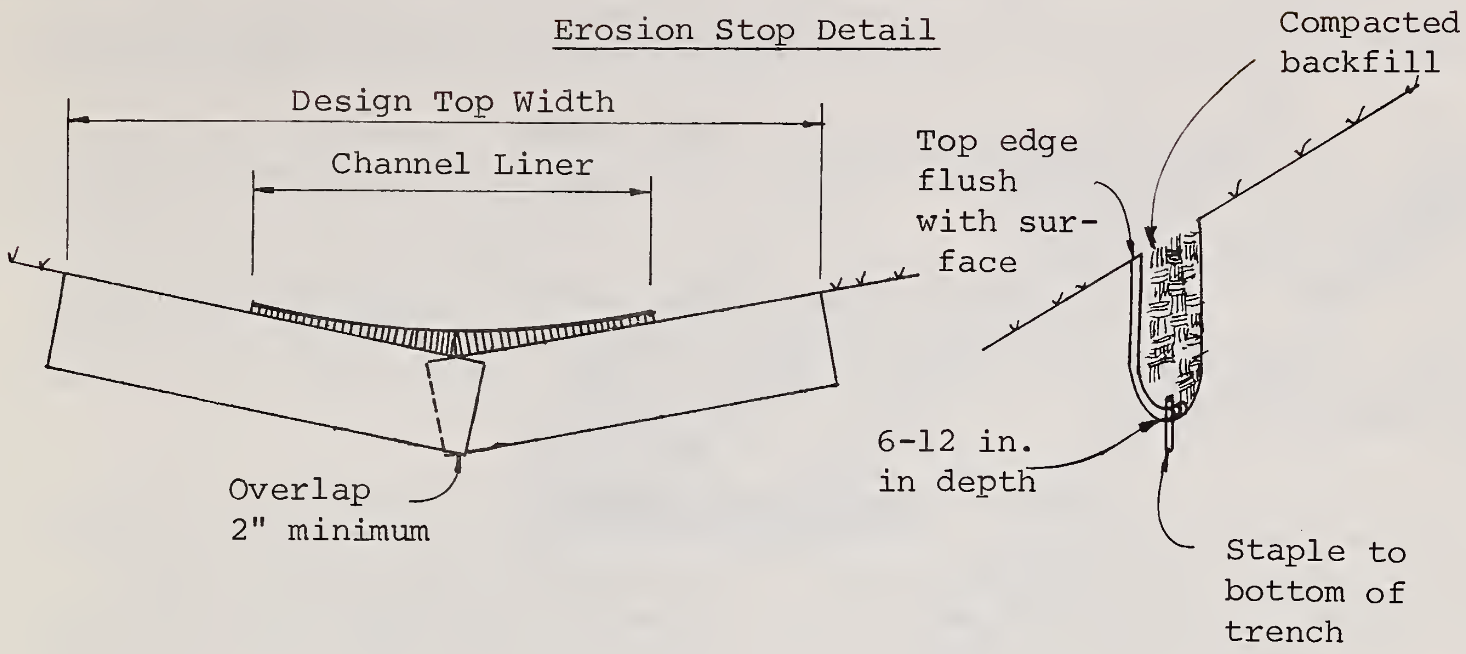
Erosion stops should extend beyond the channel liner to full design cross-section of the channel to check any rills that might form outside the channel lining.

The trench may be dug with a spade or a mechanical trencher making sure that the down slope face of the trench is flat; it should be uniform and perpendicular to line of flow to permit proper placement and stapling of the glass fiber matting.

The erosion stop should be deep enough to penetrate solid material or below level of rilling in sandy soils. In general, erosion stops will vary from 6 to 12 inches in depth.

The erosion stop mat should be wide enough to allow a minimum of 2 inch turnover at bottom of trench for stapling while maintaining the top edge flush with channel surface.

Tamp back fill firmly and to a uniform gradient of channel.



If seeding has been done prior to installation of erosion stops, reseed disturbed areas prior to placement of channel liner.

Laying Jute Matting: (If instructions have been followed, all needed erosion stops will have been installed, and the jute matting will be laid on a friable seedbed free from clods, rocks, roots, etc., that might cause bridging.)

Most channels will require multiple widths of jute matting, two widths being the most commonly used. Unroll matting starting at the upper end of the channel allowing a 4 inch overlap of mattings along center of channel.

Securing Jute Matting: Bury the top ends of jute matting in a narrow trench, minimum of 6 inch depth, similar to that used for erosion stops. Backfill trench and tamp firmly to conform to channel cross-section. Secure with a row of staples about 4 inches down slope from the trench. Spacing between staples is 6 inches.

Next, staple the 4 inch overlap in channel center using an 18 inch spacing between staples. Before stapling the outer edges of the matting, make sure the matting is smooth and in firm contact with the soil in its entirety, staples shall be placed 2 feet apart along the outer edge of matting.

Where one roll of jute matting ends and another begins, the end of the top strip shall overlap the upper end of the lower strip by 4 inches, shiplap fashion.

Where matting crosses erosion stops, reinforce with a double row of staples 6 inch spacing, staggered pattern on either side of erosion stop. Likewise, overlaps, joining the length of matting together and the discharge end of the matting liner should be similarly secured with 2 double rows of staples.

Laying and Securing Excelsior Matting: Same seedbed preparation as for jute matting with the exception that all seeding must be completed before laying excelsior matting.

Bury top ends of excelsior matting in a slit trench as described for jute matting. As the blankets are unrolled down slope, the matting must be on top with the wood fibers in contact with the soil. Butt snugly at ends and sides before stapling.

Using 2 foot spacing between staples, excelsior matting shall be secured with three rows for each strip, with one row along each edge and one alternating parallel rows down the center. The stapling over erosion stops, entrance and discharge ends of matting and butted end joints shall be the same as described for jute matting.

Final Check

1. Make sure matting is uniformly in contact with the soil.
2. All lap joints are secure.
3. All staples are flush with the ground.
4. All disturbed areas seeded.

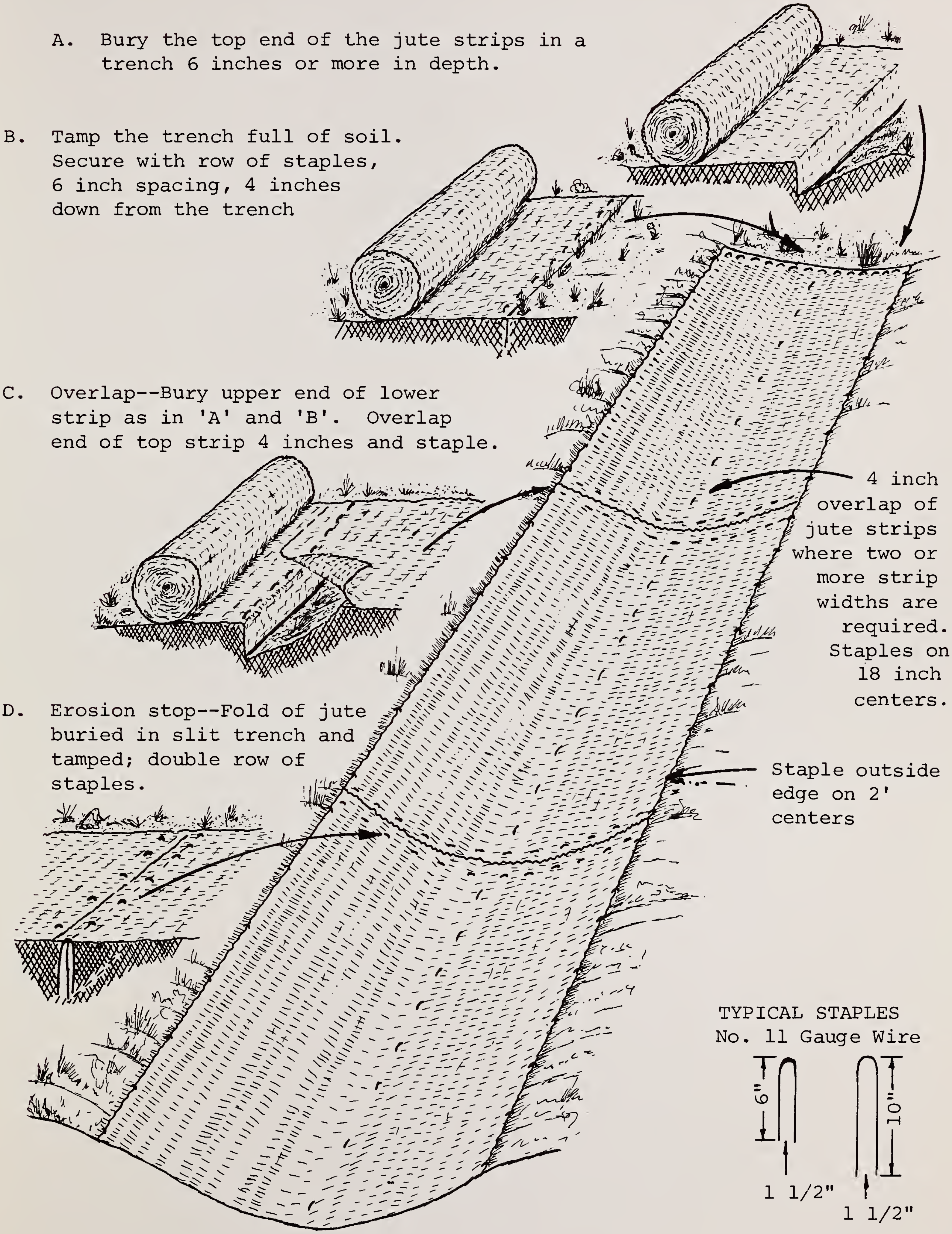
DETAIL FOR STABILIZING WATERWAYS WITH JUTE THATCHING

A. Bury the top end of the jute strips in a trench 6 inches or more in depth.

B. Tamp the trench full of soil. Secure with row of staples, 6 inch spacing, 4 inches down from the trench

C. Overlap--Bury upper end of lower strip as in 'A' and 'B'. Overlap end of top strip 4 inches and staple.

D. Erosion stop--Fold of jute buried in slit trench and tamped; double row of staples.



SECTION V

APPENDICES

(EXCEPT STRUCTURAL PRACTICES)

GRASS AND LEGUME PLANT CHARACTERISTICS

Common Name	Botanical Name	Germ. Time Days 1/	Growth Habit 2/	Season		Drainage Class					Annual Cover		pH Range	Flooding Tolerance	Erodible Areas	Waterways & Channels	Shade Tolerance	Foot Traffic	Playgrounds, Lawns Athletic Fields	Beautification	Levels of Maintenance 3/		
				Cool	Warm	Dry, (Not Droughty)	Well Drained	Mod. Well Drained	Somewhat Poorly Drained	Poorly Drained	Winter	Summer									High	Medium	Low
Redtop	Agrostis alba	5-10	Ps B	x	-	x	x	x	x	x	-	-	4.0 -7.5	x	x	x	-	x	x	-	-	x	x
Rye	Secale cereale	4-7	A	x	-	x	x	x	-	-	x	-	5.5 -7.5	-	x	-	-	-	-	-	-	x	x
Ryegrass, Italian	Lolium multiflorum	5-14	A	x	-	-	x	x	x	-	x	-	5.5 -7.5	x	x	-	x	-	-	-	-	x	x
Ryegrass, perennial	Lolium perenne	5-14	Ps B	x	-	-	x	x	x	-	-	-	5.5 -7.5	x	x	-	x	x	x	x	x	x	-
Sweetclover	Melilotus alba "officinalis"	10	Bi	x	x	x	x	x	-	-	x	x	6.5 -7.5	-	x	-	-	-	-	-	x	x	-
Sudangrass	Sorghum sudanense	4-10	A	-	x	x	x	x	x	-	-	x	4.5 -7.5	-	x	-	-	-	-	-	-	x	x
Crownvetch	Coronilla varia	14-21	PL R	x	x	x	x	x	-	-	-	-	5.5 -7.5	-	x	-	x	-	-	x	-	x	x
Lespedeza, Korean	Lespedeza stipulacea	5-14	A	-	x	x	x	x	x	-	-	x	5.5 -7.0	-	x	-	-	-	-	-	-	-	x
Lespedeza, sericea	Lespedeza cuneata	7-28	PL B	-	x	x	x	x	x	-	-	-	5.5 -7.0	-	x	-	-	-	-	-	-	x	x
Trefoil, birdsfoot	Lotus corniculatus	10	PL	x	-	x	x	x	x	-	-	-	5.0 -7.5	x	x	-	-	-	-	x	-	x	x

Notes: 1/ Germination time days - No. of days required for majority of seeds to germinate and emerge under favorable conditions.

2/ Growth Habit: A - annual; Bi - biennial; P - perennial; L - long-lived; s - short lived; R - rhizomatous or spreads by rootstocks; S - stoloniferous; B - bunch.

3/ Amount of fertilization and mowing tolerated.

GRASS AND LEGUME PLANT CHARACTERISTICS

Common Name	Botanical Name	1/ Germ. Time Days	Growth Habit 2/	Season		Drainage Class					Annual Cover		pH Range	Flooding Tolerance	Erodible Areas	Waterways & Channels	Shade Tolerance	Foot Traffic	Playgrounds, Lawns Athletic Fields	Beautification	Levels of Maintenance 3/		
				Cool	Warm	Dry, Not Droughty	Well Drained	Mod. Well Drained	Somewhat Poorly Drained	Poorly Drained	Winter	Summer									High	Medium	Low
Barley	*Hordeum vulgare*	7	A	x	-	-	x	x	-	-	x	-	5.5 -7.8	-	x	-	-	-	-	-	-	x	-
Bermudagrass	*Cynodon dactylon*	Plant Veg.	PL RS	-	x	x	x	x	x	-	-	-	4.5 -7.5	x	x	x	-	x	x	x	x	x	x
Bluegrass, Kentucky	*Poa pratensis*	10-28	PL R	x	-	-	x	x	x	-	-	-	5.5 -7.0	x	x	x	-	x	x	x	x	x	x
Canarygrass, Reed	*Phalaria arundinacea*	5-21	PL R	x	-	x	x	x	x	x	-	-	5.0 -7.5	x	x	x	-	-	-	-	x	x	x
Fescue, creeping red	*Festuca rubra*	7-21	PL R	x	-	x	x	x	x	-	-	-	4.5 -7.5	x	x	x	x	x	x	x	x	x	x
Fescue, Chewings red	*Festuca comutata*	7-14	PL	x	-	x	x	x	x	-	-	-	4.5 -7.5	x	x	x	x	x	x	x	x	x	x
Fescue, Tall ('Ky-31')	*Festuca arundinacea*	5-14	PL BR	x	-	-	x	x	x	-	-	-	5.0 -8.0	x	x	x	x	x	x	x	x	x	-
Lovegrass, Weeping	*Eragrostis curvula*	5-14	Ps B	-	x	x	x	x	x	-	-	-	4.5 -8.0	-	x	-	-	-	-	-	x	x	x
Millet	*Setaria and Pennisetum spp.*	4-14	A	-	x	x	x	x	x	-	-	x	4.5 -7.0	-	x	-	-	-	-	-	-	-	x
Oats	*Avena sativa*	5-10	A	x	-	-	x	x	-	-	x	-	5.5 -7.0	-	x	-	-	-	-	-	-	x	-

Notes: 1/ Germination time days - No. of days required for majority of seeds to germinate and emerge under favorable conditions.

2/ Growth Habit: A - annual; Bi - biennial; P - perennial; L - long-lived; s - short-lived; R - rhizomatous or spreads by rootstocks; S - stoloniferous; B - bunch.

3/ Amount of fertilization and mowing tolerated.

APPENDIX B-2

EXAMPLE SEED SPECIFICATIONS

A. The seed mixtures and specifications shall meet the minimum requirements as specified below.

1. Furnish the kinds and amounts of seed as indicated below to be seeded in all areas designated.

   (List mixtures and amounts of each species here).

2. The minimum requirements for grass and legume seed used in the vegetative work are as follows:

   a. All seed must meet the requirements of the Maryland State Seed Law.

   b. All seed shall be subject to re-testing by a recognized seed laboratory.

   c. All seed used shall have been tested within the six (6) months immediately preceding the date of sowing such material on this job.

   d. Inoculant - The inoculant for treating legume seed in the seed mixtures shall be a pure culture of nitrogen-fixing bacteria prepared specifically for the species. Inoculants shall not be used later than the date indicated on the container. Twice the supplier's recommended rate of inoculant will be used on dry seedings; four times the recommended rate if hydroseeded.

   e. The quality of the seed used shall conform to the following guidelines as shown on B2.02. Bag tags will be the source of this quality and testing information.

Quality of Seed*

LEGUMES	Minimum Seed Purity (%)	Minimum Germination (%)
Birdsfoot trefoil	98	80
Crownvetch	95	65
Lespedeza, Korean	97	85
Lespedeza, Sericea	98	85
Sweetclover	98	85
GRASSES		
Bluegrass, Canada	80	80
Bluegrass, Kentucky	80	85
Fescue, red	97	80
Fescue, tall 'Ky-31'	97	85
Lovegrass, weeping, Boer, Lehmann's	95	87
Redtop	90	85
Reed canarygrass	96	80
Ryegrass, Italian	98	85
Ryegrass, perennial	98	85
OTHER ANNUALS		
Barley	98	90
Millet	99	80
Oats	98	80
Rye	98	80
Sudangrass (non hybrids)	98	80

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* Seed containing prohibited or restricted noxious weeds should not be accepted.

Prohibited noxious weeds - Johnsongrass or Johnsongrass crosses, Canada thistle, and quackgrass.

Restricted noxious weeds - Wild garlic and wild onion, bermudagrass, annual bluegrass, corn cockle, dodder and bindweed.

Seed should not contain in excess of 2.50 percent of weed seeds; none is desirable.

To calculate percent pure live seed, multiply germination times purity and divide by 100.

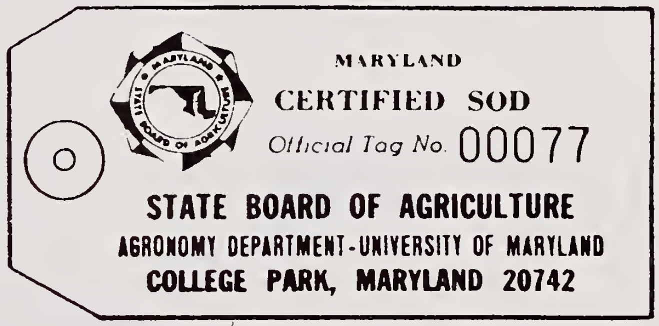
Example: 'Ky-31' tall fescue with a germination of 85 percent and a purity of 97 percent. 97 x 85 = 8245. 82.45 ÷ 100 = 82.45 percent pure live seed.

APPENDIX B-3. EXPLANATION OF CLASSES OF TURFGRASS SOD

1. State "Certified Sod"

"Certified" turfgrass sod is superior sod grown from "Certified" seed. It is inspected and certified by the State Certifying Agency to insure genetic purity, overall high quality and freedom from noxious weeds as well as excessive amounts of other crop and weed plants at the time of harvest. It may be composed of a mixture of two or more varieties or species. The sod must meet published state standards and bear an official Maryland, Virginia, or other state "Certified Sod" label on the bill of lading. The purchaser should require such labels when sod is delivered.

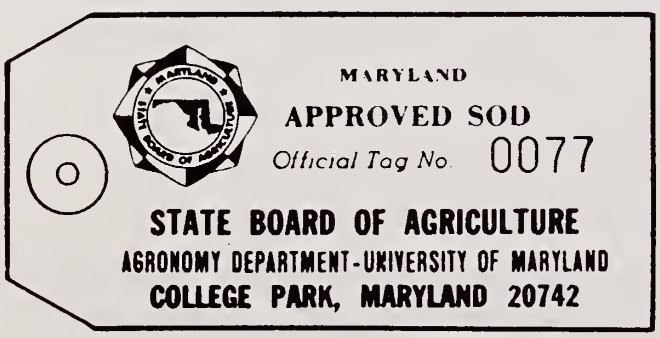
Specimen "Certified" Labels for Maryland and Virginia



2. State "Approved Sod"

"Approved" turfgrass sod is inspected and approved by the State Certifying Agency to insure overall high quality and freedom from noxious weeds and excessive amounts of other crop and weed plants at the time of harvest. It may be composed of a mixture of two or more varieties or species. The sod must meet published state standards and bear an official Maryland or Virginia "Approved Sod" label on the bill of lading. The purchaser should require such labels when sod is delivered.

Specimen "Approved" Labels for Maryland and Virginia



3. Other Sod

The architect should provide detailed quality specifications for all sod other than State "Certified" or "Approved" classes. Such specifications should include species and/or varieties and the following quality standards: weed content, other crop contaminants, thatch, diseases, insects, mowing height, uniformity and overall quality. These quality standards are automatically covered in the State "Certified" and "Approved" classes. If assistance is needed in developing quality standards for other sod, contact the County Extension Agent in the county where the work is to be performed.

Reference: Md-Va Pub. #1, Guideline Specifications, Soil Preparation and Sodding. Cooperative Extension Service, University of Maryland and Virginia Polytechnic Institute. December 1969.

APPENDIX B-4

EXPLANATION OF COMPOSITION OF TURFGRASS SOD 3/

The following mixtures of species and varieties are eligible for the State "Certified" and State "Approved" classes of sod in Maryland.

NO. 1 SUNNY TURF AREAS

a. Kentucky Bluegrass
20-60% Certified 'Merion'
20-40% Certified 'Kenblue' (Ky. origin)
or 'South Dakota Certified'
0-40% Certified 'Fylking', Certified 'Pennstar'
or Certified 'Adelphi'

b. 'Tufcote' bermudagrass 2/
100%

NO. 2 GENERAL PURPOSE TURF AREAS
(Droughty or Shaded Areas)

a. Kentucky Bluegrass
20-60% Certified 'Merion'
20-40% Certified 'Kenblue' (Ky. origin)
or 'South Dakota Certified'
0-40% Certified 'Fylking', Certified 'Pennstar'
or Certified 'Adelphi'

Red Fescue 1/
10-50% Certified 'Pennlawn' or Certified
'Jamestown'

b. 'Tufcote' bermudagrass 2/
100% (Not in shade)

NO. 3 MULTI-USE TURF AREAS
(Athletic Fields, Lawns, Parks, Playgrounds)

a. Tall Fescue
90-100% Certified 'Kentucky 31'

Kentucky Bluegrass
0-10% Certified 'Kenblue' (Ky. origin),
'South Dakota Certified', or
Certified 'Merion"

b. 'Tufcote' bermudagrass 2/
100% (Not in shade)

1/ If the lawn is under heavy shade, use the higher percentage of red fescue.
2/ Sod is expensive - Use of stolons is more practical.
3/ Based on University of Maryland Agronomy Mimeo. No. 77; Subject to frequent revision.

SECTION VI

GLOSSARY

GLOSSARY (50)

AASHTO - American Association of State Highway & Transportation Officials (Formerly AASHO)

ACCEPTABLE OUTLET - That point where storm water runoff can be released into a watercourse or drainage way of adequate capacity without causing scour or erosion.

ACID SOIL - A soil giving an acid reaction throughout most or all of the portion occupied by roots. (Precisely, below a pH of 7.0; practically, below a pH of 6.6.

ALLUVIAL FAN - A sloping, fan-shaped mass of sediment deposited by a stream where it emerges from an upland onto a plain.

ALLUVIUM - A general term for all detrital material deposited or in transit by streams, including gravel, sand, silt, clay and all variations and mixtures of these. Unless otherwise noted, alluvium is unconsolidated.

ANGLE OF REPOSE - The angle between the horizontal and the maximum slope that a soil assumes through natural processes.

ANTI-SEEP COLLAR - An impermeable diaphragm usually of sheet metal or concrete constructed at intervals within the zone of saturation along the conduit of a principal spillway to increase the seepage length along the conduit and thereby prevent piping or seepage along the conduit.

ANTI-VORTEX DEVICE - A device, usually a vertical or horizontal plate, carefully designed and placed at the entrance of a pipe to prevent the formation of a vortex in the water at the pipe entrance.

APRON - A floor or lining to protect a surface from erosion, for example, the pavement below chutes, spillways, or at the toes of dams.

ASPECT - The direction a slope faces is a physiographic feature on steep slopes which influences plant growth and adaptation.

ASPHALT

a. Cutback - Asphalt thinned with lighter hydrocarbons such as kerosene or naphtha.
b. Emulsion - An emulsion of water and asphalt.
c. Liquid - (in this application) Asphalt which has a sufficiently low viscosity to be sprayed without thinning.

ATTERBERG LIMITS - Atterberg limits are soil properties measured for soil materials passing the No.40 sieve.

Liquid Limit (LL) - The liquid limit is the water content corresponding to the arbitrary limit between the liquid & plastic states of consistency of a soil.

Plastic Limit (PL) - The plastic limit is the water content corresponding to an arbitrary limit between the plastic and semisolid states of consistency of a soil.

Plasticity Index (PI) - The plasticity index is the numerical difference between the liquid limit and plastic limit.

BAFFLES - Vanes, guides, grids, grating or similar devices placed in a conduit to deflect or regulate flow and effect a more uniform distribution of velocities.

BARREL - The usually mildly sloping closed conduit used to convey water under or through a dam; part of a principal spillway.

BASE FLOW - The stream discharge from ground water accretion.

BEDLOAD - The sediment that moves by sliding, rolling or bounding on or very near the streambed; sediment moved mainly by tractive or gravitational forces or both but at velocities less than the surrounding flow.

BERM - A shelf that breaks the continuity of a slope.

BIODEGRADABLE - Capable of being broken down (degraded) by common soil organisms.

BLIND DRAIN - A type of drain consisting of an excavated trench refilled with pervious material, such as coarse sand, gravel or crushed stone, through whose voids water percolates and flows to an outlet. Often referred to as a French drain because of its initial development and widespread use in France.

BLOOMY - Having a whitish powdery, usually waxy coating on foliage.

BRACKISH (WATER) - Slightly to moderately salty water.

BULKHEAD - A wall made from wood, steel, concrete, etc. for protection of shoreline from waves or currents.

CALCIUM SULFATE - Gypsum. A hydrated form used to treat high sodium soils. $CaSO_4 \cdot 2H_2O$

CHANNEL - A natural stream that conveys water; a ditch or channel excavated for the flow of water.

CHANNEL IMPROVEMENT - The improvement of the flow characteristics of a channel by clearing, excavation, realignment, lining, or other means in order to increase its water carrying capacity.

CHANNEL STABILIZATION - Erosion prevention and stabilization of velocity distribution in a channel using jetties, drops, revetments, structural linings, vegetation and other measures.

CHANNEL STORAGE - Water temporarily stored in channels while enroute to an outlet.

CHECK DAM - A small dam constructed in a gully or other small watercourse to decrease the streamflow velocity (by reducing the channel gradient), minimize channel scour, and promote deposition of sediment.

CHUTE - A high velocity, open channel for conveying water to a lower level without erosion.

CLAY (SOILS) - 1: A mineral soil separate consisting of particles less than 0.002 millimeter in equivalent diameter. 2: A soil textural class. 3: (engineering) A fine grained soil (more than 50 percent passing the No. 200 sieve) that has a high plasticity index in relation to the liquid limit. (Unified Soil Classification System)

COMPACTION - To unite firmly. With respect to construction work with soils, engineering compaction is any process by which the soil grains are rearranged to decrease void space and bring them into closer contact with one another, thereby increasing the weight of solid material per unit of volume, increasing the shear and bearing strength and reducing permeability.

COMPOST - A mixture of vegetable refuse, manure or other organic matter which has gone through a decaying process.

CONDUIT - Any channel intended for the conveyance of water, whether open or closed.

CONTOUR - 1: An imaginary line on the surface of the earth connecting points of the same elevation. 2: A line drawn on a map connecting points of the same elevation.

COOL (SLOPE, EXPOSURE) - A slope facing north or east, or a slope shaded during the hot part of the day.

CORDGRASS - Grasses of genus Spartina which are so named because of seed heads which have the appearance of coarse cord. These grasses are important soil binders along saltwater shorelines and marshes.

CORE TRENCH - See cutoff.

CRADLE (ENGINEERING) - A structure usually of concrete shaped to fit around the bottom and sides of a conduit to support the conduit, increase its strength and in dams, to fill all voids between the underside of the conduit and the soil.

CREST - 1: The top of a dam, dike, spillway or weir, frequently restricted to the overflow portion. 2: The summit of a wave or peak of a flood.

<u>CRITICAL AREA OR SITE</u> - Sediment producing, highly erodible or severely eroded areas.

<u>CRITICAL DEPTH (HYDRAULICS)</u> - Depth of flow in a channel of specified dimensions at which specific energy is a minimum for a given discharge.

<u>CRITICAL SLOPE (HYDRAULICS)</u> - That slope which will sustain a given discharge at uniform critical depth in a given channel.

<u>CROWN (OF SLOPE)</u> - Top of slope; Apex.

<u>CRUSHED STONE</u> - Aggregate consisting of angular particles produced by mechanically crushing rock.

<u>CULM</u> - The stem of grasses, sedges and rushes which is jointed and usually hollow in grasses and usually solid in sedges and rushes.

<u>CULTIPACKER</u> - A corrugated roller used to crush clods, and eliminate coarse pores in soil by firming the seedbed.

<u>CULTIPACKER SEEDER</u> - In addition to being a cultipacker, (which see) this is a farm tool equipped with a seedbox which drops the seed between cultipacker rollers to place the seed on firm soil where they will be pressed into the soil by the second corrugated roller.

<u>CUT</u> - Portion of land surface or area from which earth has been removed or will be removed by excavation; the depth below original ground surface to excavated surface.

<u>CUT-AND-FILL</u> - Process of earth moving by excavating part of an area and using the excavated material for adjacent embankments or fill areas.

<u>CUTOFF</u> - A wall or other structure, such as a trench, filled with relatively impervious material intended to reduce seepage of water through porous strata.

<u>CUTTINGS</u> - A small shoot cut from a plant to start a new plant.

<u>CYCLONE (SEEDER)</u> - A hand turned or tractor drawn seeder that broadcasts seed onto the seedbed by a rotary motion that slings the seed outward from the seeder.

<u>DAM</u> - A barrier to confine or raise water for storage or diversion, to create a hydraulic head, to prevent gully erosion, or for retention of soil, sediment or other debris.

<u>DEBRIS</u> - Broken remains of plants, objects & rocks that form trash or remains.

<u>DECIDUOUS</u> - Plants that shed their leaves annually as opposed to evergreen.

DEPOSITION - The accumulation of material dropped because of a slackening movement of the transporting agent, water or wind.

DESICCATION - Drying out as of root systems of plants before they are planted.

DESILTING AREA - An area of grass, shrubs or other vegetation used for inducing deposition of silt and other debris from flowing water, located above a pond, field or other area needing protection from sediment accumulation. See filter strip.

DETENTION DAM - A dam constructed for the purpose of temporary storage of streamflow or surface runoff which releases the stored water at controlled rates.

DIKE - (ENGINEERING) - An embankment to confine or control water, for example, one built along the banks of a river to prevent overflow of lowlands; a levee.

DISTINCT (BLOOM) - Blossoms of plants that are readily noticed.

DISTURBED AREA - An area in which the natural vegetative soil cover has been removed or altered, and therefore, is susceptible to erosion.

DIVERSION - A channel with a supporting ridge on the lower side constructed across the slope to divert water from areas where it is in excess to sites where it can be used or disposed of safely. Diversions differ from terraces in that they are individually designed.

DOLOMITIC (LIMESTONE) - Liming materials that contain more than 6 percent magnesium (mg); High magnesium lime.

DRAIN (NOUN) - 1: A buried pipe or other conduit (subsurface drain). 2: A ditch or channel (open drain) for carrying off surplus surface water or groundwater.

DRAIN (VERB)- 1: To provide channels, such as open ditches or closed drains, so that excess water can be removed by surface flow or internal flow. 2: To lose water (from the soil) by percolation.

DRAINAGE - 1: The removal of excess surface water or ground water from land by means of surface or subsurface drains. 2: Soil characteristics that affect natural drainage.

DRAINAGE AREA (WATERSHED) - All land and water area from which runoff may run to a common (design) point.

DROP INLET SPILLWAY - An overfall structure in which the water drops through a vertical riser connected to a discharge conduit.

DROP SPILLWAY - An overfall structure in which the water drops over a vertical wall onto an apron at a lower elevation.

DROP STRUCTURE - A structure for dropping water to a lower level and dissipating its surplus energy; a fall. The drop may be vertical or inclined.

DROUGHTY (SOIL OR SLOPE) - Lacking medium to high moisture during part of the poor growing season during a typical year.

EMERGENCY SPILLWAY - A dam spillway designed and constructed to discharge flow in excess of the principal spillway design discharge.

ENERGY DISSIPATOR - A designed device such as an apron of riprap or a concrete structure placed at the end of a water transmitting apparatus such as a pipe, paved ditch or paved chute for the purpose of reducing the velocity, energy and turbulence of the discharged water.

ENTRANCE HEAD - The head required to cause flow into a conduit or other structure, including both entrance loss and velocity head.

EROSION - 1: The wearing away of the land surface by running water, wind, ice, or other geological agents, including such processes as gravitational creep. 2: Detachment and movement of soil or rock fragments by water, wind, ice or gravity. The following terms are used to describe different types of water erosion:

Accelerated erosion - Erosion much more rapid than normal, natural or geologic erosion, primarily as a result of the influence of the activities of man or, in some cases, of other animals or natural catastrophies that expose base surfaces, for example, fires.

Gully erosion - The erosion process whereby water accumulates in narrow channels and, over short periods, removes the soil from this narrow area to considerable depths, ranging from 1 or 2 feet to as much as 75 to 100 feet. See gully.

Rill erosion - An erosion process in which numerous small channels only several inches deep are formed. See rill.

Sheet erosion - The removal of a fairly uniform layer of soil from the land surface by runoff water.

Splash erosion - The spattering of small soil particles caused by the impact of raindrops on wet soils. The loosened and spattered particles may or may not be subsequently removed by surface runoff.

ESTHETIC (AESTHETIC) - Pleasing to look at.

EVERGREEN - Plants which have leaves or needles yearlong as opposed to those that lose their leaves during part of the year.

EXCELSIOR BLANKET - An erosion retardant material made from excelsior strands held together with net-like strands of plastic or other material.

EXPOSURE (SLOPE) -

a. North - Slopes facing in any compass direction clockwise between N45W and S45E.

b. South - Those slopes which face in any compass direction clockwise between S45E and N45W.

FERRUGINOUS - Iron bearing: Usually refers to material of comparatively high iron oxide content.

FILTER STRIP - A strip of permanent vegetation above ponds, diversions and other structures to retard flow of runoff water, causing deposition of transported material, thereby reducing sediment flow.

FINES (SOIL) - Generally refers to the silt and clay size particles in soil.

FREEBOARD (HYDRAULICS) - The vertical distance between the maximum water surface elevation anticipated in design and the top of retaining banks or structures. Freeboard is provided to prevent overtopping due to unforeseen conditons.

FRONTAL DUNES - That row of dunes facing the ocean or other large body of water. Primary dunes.

GABION - A flexible woven-wire basket composed of two to six rectangular cells filled with small stones. Gabions may be assembled into many types of structures such as revetments, retaining walls, channel liners, drop structures and groins.

GABION MATTRESS - A thin gabion, usually six or nine inches thick, used to line channels for erosion control.

GRADE - 1: The slope of a road, channel or natural ground. 2: The finished surface of a canal bed, roadbed, top of embankment, or bottom of excavation; any surface prepared for the support of construction, like paving or laying a conduit. 3: To finish the surface of a canal bed, roadbed, top of embankment or bottom of excavation.

GRADE STABILIZATION STRUCTURE - A structure for the purpose of stabilizing the grade of a gully or other watercourse, thereby preventing further head cutting or lowering of the channel grade.

GRAFTING - A method of propogating plants by joining wood from one plant to another plant to get more desirable growth on the second plant.

GRASSED WATERWAY - A natural or constructed waterway, usually broad and shallow covered with erosion resistant grasses, to convey surface water down the slope.

GRAVEL - 1: Aggregate consisting of mixed sizes of 1/4 inch to 3 inch particles which normally occur in or near old streambeds and have been worn smooth by the action of water. 2: A soil having particle sizes, according to the Unified Soil Classification System, ranging from the No. 4 sieve size (approximately 1/4 inch) to 3 inches. Particles may be natural gravel or angular in shape as produced by mechanical crushing.

GRAVEL ENVELOPE - Selected aggregate placed around the screened or perforated pipe section of well casing or a subsurface drain to facilitate the entry of water into the well or drain.

GRAVEL FILTER - Washed and graded sand and gravel aggregate placed around a drain or well screen to prevent the movement of fine materials from the aquifer into the drain or well.

GROIN - A shore protection structure built (usually perpendicular to the shoreline) to trap littoral drift or retard erosion of the shoreline.

GROUND COVER - Plants which are low-growing and provide a thick growth which protects the soil as well as providing some beautification of the area occupied.

GULLY - A channel or miniature valley cut by concentrated runoff through which water commonly flows only during and immediately after heavy rains or during the melting of snow. The distinction between gully and rill is one of depth. A gully is sufficiently deep that it would not be obliterated by normal tillage operations, whereas a rill is of lessor depth and would be smoothed by ordinary farm tillage.

GYPSUM - A hydrated form of calcium sulfate having a formula of $CaSO_4 \cdot 2H_2O$

HARDEN OFF - Applying high phosphorous and potash fertilizer, in relation to nitrogen, causing plants to lose succulence; usually done before winter sets in, to lessen winter kill of plants.

HEAD (HYDRAULICS) - 1: The height of water above any plane or reference. 2: The energy, either kinetic or potential, possessed by each unit weight of a liquid expressed as the vertical height through which a unit weight would have to fall to release the average energy possessed. Used in various compounds terms such as pressure head, velocity head, and head loss.

HERBACEOUS PERENNIAL (PLANTS) - A plant whose stems die back to the ground each year.

HERBICIDE - Chemical formulations used to control weeds or brush.

HOT (REFERENCE TO SLOPE) - A slope facing in the direction from compass point S45E clockwise to N45W.

HULLED (SEED) - Hulless seed, such as sericea lespedeza. Seed are usually processed after threshing to take off outer hull to facilitate scarification and quicken germination.

HYDRAULIC GRADE LINE - In a closed conduit a line joining the elevations to which water could stand in risers or vertical pipes connected to the conduit at their lower end and open at their upper end. In open channel flow, the hydraulic grade line is the free water surface.

HYDRAULIC GRADIENT - The slope of the hydraulic grade line. The slope of the free surface of water flowing in an open channel.

HYDRAULIC JUMP - The sudden turbulent rise in water level from a flow stage below critical depth to flow stage above critical depth, during which the velocity passes from super critical to subcritical.

HYDRAULIC RADIUS - The cross sectional area of a channel divided by its wetted perimeter. The "r" in Manning's Formula.

HYDROGRAPH - A graph showing variation in stage (depth) or discharge of a stream of water over a period of time.

HYDROSEEDER - A machine designed to apply seed, fertilizer, lime and short fiber wood or paper mulch to the soil surface.

HYDRO-SEEDING - Seeding with a hydroseeder.

IMPACT BASIN - A type of energy dissipator that has a vertical impact wall inside a concrete structure, specifically the U.S. Bureau of Reclamation Type VI basin.

INDISTINCT - Blossoms are not readily noticed as opposed to large, showy blossoms.

INLET (HYDRAULICS) - 1: A surface connection to a closed drain. 2: A structure at the entrance end of a conduit. 3: The upstream end of any structure through which water may flow.

INTERCEPTOR DRAIN - A surface or subsurface drain, or a combination of both, designed and installed to intercept flowing water.

ISOBUTYLIDENE UREA - (IBDU) - A slowly soluble synthetic organic containing 31 percent nitrogen.

JUTE - A coarsly woven material of jute yarn which can be used to control soil erosion in waterways and on steep slopes.

LAYERING - A shoot or twig attached to the living stock for the purpose of propagation.

LIME - Basic calcareous materials used to raise pH of acid soils for benefit of plants being grown. May be either ground limestone or hydrated lime.

LITTORAL DRIFT - The sedimentary material moved in the littoral zone under the influence of waves and currents.

MAJOR LAND RESOURCE AREAS - Consists of geographically associated land resource units. (See below)

MAJOR LAND RESOURCE UNITS - Geographic areas of land, usually several thousand acres in extent, that are characterized by particular patterns of soil (including slope and erosion), climate, water resources, land use and type of farming.

MANNING'S FORMULA (HYDRAULICS) - A formula used to predict the velocity of water flow in an open channel or pipeline:

$$V=\frac{1.486}{n} R^{2/3} S^{1/2}$$

Wherein V is the mean velocity of flow in feet per second; R is the hydraulic radius; S is the slope of the energy gradient or for assumed uniform flow the slope of the channel, in feet per foot; and n is the roughness coefficient or retardance factor of the channel lining.

MSHA - Maryland State Highway Administration.

MULCH - Covering on surface of soil to protect and enhance certain characteristics, such as water retention qualities.

MULCH ANCHORING TOOL - A tool that looks like a dull disk designed to press straw and similar mulches into the soil to prevent loss due to wind, water or gravity.

NATIVE (GRASSES) - Naturally occurring; not introduced from other countries.

NATURAL GROUND - Ground surface which has not been disturbed by man.

NETTING (MULCH) - Plastic, paper or cotton material used to hold mulch material on the soil surface.

NITROGEN - FIXING (BACTERIA) - Bacteria having the ability to fix atmospheric nitrogen, making it available for use by plants. Inoculation of legume seeds is one way to insure a source of these bacteria for specified legumes.

NORMAL DEPTH - Depth of flow in an open conduit during uniform flow for the given conditions. See uniform flow.

NOXIOUS WEEDS - Harmful; undesirable; hard to control.

a. Restricted - May be sold in the trade but are limited to very small amounts as undesirable contaminates.
b. Prohibited - Prohibited from sale.

OUTFALL - The point where water flows from a conduit, stream or drain.

OUTLET - The point at which water discharges from such things as a stream, river, lake, tidal basin, pipe, channel or drainage area.

OUTLET CHANNEL - A waterway constructed or altered primarily to carry water from man-made structures such as terraces, subsurface drains, diversions and impoundments.

OVATE - Egg-shaped in outline and attached at the wide end.

OVERFALL - Abrupt change in stream channel elevation; the part of a dam or weir notch over which the water flows.

OVOID - A 3-dimensional solid, ovate in outline.

PADS - Individual pieces of sod cut to supplier's standard width and length.

PAPER FIBER - A short fiber mulch material usually applied by hydroseeder along with fertilizer and seed.

PARENT MATERIAL - The unconsolidated rock material from which the soil profile develops.

PENDULOUS - More or less hanging or inclined downward.

PERMANENT SEEDING - Results in establishing perennial vegetation which may remain on the area for many years.

PERMISSIBLE VELOCITY (HYDRAULICS) - The highest average velocity at which water may be carried safely in a channel or other conduit. The highest velocity that can exist through a substantial length of a conduit and not cause scour of the channel. Syn. safe, noneroding or allowable velocity.

pH - A number denoting the common logarithm of the reciprocal of the hydrogen ion concentration. A pH of 7.0 denotes neutrality, higher values indicate alkalinity, and lower values indicate acidity.

PHREATIC LINE - The upper surface of the zone of saturation in an embankment is the phreatic (zero pressure) surface; in cross-section, this is called the phreatic line.

PIPING - Removal of soil material through subsurface flow channels or "pipes" developed by seepage water.

PLASTICITY INDEX - See Atterberg limits.

PLASTIC LIMIT - See Atterberg limits.

PLUGS - Pieces of turf or sod, usually cut with a round tube, which can be used to propagate the turf or sod by vegetative means.

PRESS WHEEL - A wheel which usually follows a seeding and presses seed into or on the surface of the seedbed.

PROCUMBENT - Lying down prone; trailing as a vine, usually not rooting at the nodes.

PROJECTION - In sediment basins or other dams the perpendicular distance that the anti-seep collar extends from the outside surface of the pipe or pipe cradle.

RAMPANT (GROWER) - Wild, unchecked climber; exceeding usual limits.

RESIDUES (PLANT) - Dead parts of plants which may be left on the soil surface following harvest, grazing or cutting.

RETENTION - The amount of precipitation on a drainage area that does not escape as runoff. It is the difference between total precipitation and total runoff.

REVETMENT - Facing of stone or other material, either permanent or temporary, placed along the edge of a stream or shoreline to stabilize the bank and to protect it from the erosive action of water.

RHIZOME - Any prostrate, more or less elongated stem growing partly or completely beneath the surface of the ground; usually rooting at the nodes and becoming upcurved at the apex.

RIGHT-OF-WAY - Right of passage, as over another's property. A route that is lawful to use. A strip of land acquired for transport or utility construction.

RILL - A small channel cut by concentrated runoff but through which water commonly flows only during and immediately after rains or during the melting of snow. A rill is usually only a few inches deep (but no more than a foot) and, hence, no obstacle to tillage operations.

RIPPING - Pulling a chisel or subsoiling implement through the soil to reduce compaction and promote infiltration of water into the soil. Does not invert the soil.

RIPRAP - Broken rock, cobbles, or boulders placed on earth surfaces, such as the face of a dam or the bank of a stream, for protection against the action of water (waves); also applies to brush or pole mattresses, or brush and stone, or similar materials used for soil erosion control.

ROUGHNESS COEFFICIENT (HYDRAULICS) - A factor in velocity and discharge formulas representing the effect of channel roughness on energy losses in flowing water. Manning's "n" is a commonly used roughness coefficient.

RUNOFF (HYDRAULICS) - That portion of the precipitation on a drainage area that is discharged from the area in stream channels. Types include surface runoff, ground water runoff or seepage.

SALINE SOIL - A non-alkali soil containing sufficient soluble salts to impair plant growth.

SAND - 1: (Agronomy) A soil particle between 0.05 and 2.0 millimeters in diameter. 2: A soil textural class. 3: (Engineering) According to the Unified Soil Classification System, a soil particle larger than the No.200 sieve (0.074mm) and passing the No.4 sieve (approximately 1/4 inch).

SCRAMBLING (VINE) - Fast, disorganized growth.

SEDIMENT - Solid material, both mineral and organic, that is in suspension, is being transported, or has been moved from its site of origin by air, water, gravity, or ice and has come to rest on the earth's surface either above or below sea level.

SEDIMENTATION - Deposition of detatched soil particles.

SEDIMENT DISCHARGE (SEDIMENT LOAD) - The quantity of sediment, measured in dry weight or by volume, transported through a stream cross-section in a given time. Sediment discharge consists of both suspended load and bedload.

SEEPAGE - 1: Water escaping through or emerging from the ground. 2: The process by which water percolates through the soil.

SEEPAGE LENGTH - In sediment basins or ponds, the length along the pipe and around the anti-seep collars that is within the seepage zone through an embankment. See "phreatic line".

SHEET FLOW - Water, usually storm runoff, flowing in a thin layer over the ground surface.

SIDE SLOPES (ENGINEERING) - The slope of the sides of a canal, dam or embankment. It is customary to name the horizontal distance first, as 1.5 to 1, or frequently, 1 1/2 : 1, meaning a horizontal distance of 1.5 feet to 1 foot vertical.

SILT - 1: (Agronomy) A soil separate consisting of particles between 0.05 and 0.002 millimeter in equivalent diameter. 2: A soil textural class. 3: (Engineering) According to the Unified Soil Classification System a fine grained soil (more than 50 percent passing the No. 200 sieve) that has a low plasticity index in relation to the liquid limit.

SLURRY - A thickened, aqueous mixture of such things as seed, fertilizer, short fiber mulch or soil.

SMALL GRAIN MULCH MATERIAL - Straw material from oats, barley, wheat, or rye.

SOD - A piece of earth containing grass plants with their matted roots. Turf.

SODDED WATERWAY - A grassed waterway vegetated by sodding with adapted species of grasses.

SOIL - 1: (Agronomy) The unconsolidated mineral and organic material on the immediate surface of the earth that serves as a natural medium for the growth of land plants. 2: (Engineering) Earth and rock particles resulting from the physical and chemical disintegration of rocks, and may or may not contain organic matter. It includes fine material (silts & clays), sand and gravel.

SOIL TEST - Chemical analysis of soil to determine needs for fertilizers or amendments for species of plants being grown.

SPECIFIC ENERGY - The energy of a stream referred to its bed, namely, depth plus velocity head of mean velocity.

SPILLWAY - An open or closed channel, or both, used to convey excess water from a reservoir. It may contain gates, either manually or automatically controlled to regulate the discharge of excess water.

SPREADER (HYDRAULICS) - A device for distributing water uniformly in or from a channel.

SPRIG - A piece of rhizome or stolon without soil which may be used to vegetatively progagate plants such as bermudagrass.

STABILIZATION - Providing adequate measures, vegetative and/or structural that will prevent erosion from occurring.

STABILIZED AREA - An area sufficiently covered by erosion resistant material such as a good cover of grass, or paving by asphalt, concrete or stone, in order that erosion of the underlying soil does not occur.

STABILIZED GRADE - The slope of a channel at which neither erosion nor deposition occurs.

STABLE (STREAM OR CHANNEL) - The condition of a stream, channel or other water course in which no erosion or deposition occurs; adequately protected from erosion.

STAGE (HYDRAULICS) - The variable water surface or the water surface elevation above any chosen datum.

STARVED (SHORELINES) - Shores which have receded or are receding due to losing more materials to waves and currents than is being deposited.

STATIC HEAD - Head resulting from elevation differences, for example, the difference in elevation in headwater and tailwater in a hydroelectric plant.

STILLING BASIN - An open structure or excavation at the foot of an overfall, conduit, chute, drop, or spillway to reduce the energy of the descending

stream of water.

STOLON - A trailing or reclining above ground stem capable of rooting and/or sending up new shoots from the nodes.

STRAGGLING - Growing in a spread out or unplanned order.

STRUCTURAL - Relating to something constructed or built by man.

STRUCTURE (SOIL) - The combination or arrangement of primary soil particles into secondary particles, units or peds. (Dune sand is structureless)

SUBCRITICAL FLOW - Flow at velocities less than critical velocity.

SUBGRADE - The soil prepared and compacted to support a structure or a payment system.

SUBSOIL - Roughly that part of the soil below plow depth.

TAILWATER (HYDRAULICS) - Water, in a river or channel, immediately downstream from a structure.

TEMPORARY SEEDING - A seeding which is made to provide temporary cover for the soil while waiting for further construction or other activity to take place.

TERRACE - An embankment or combination of an embankment and channel constructed across a slope at a suitable spacing to control erosion by diverting or storing surface runoff instead of permitting it to flow uninterrupted down the slope. Normally used only on cropland.

TEXTURE (SOIL) - The relative proportions of various soil separates in a soil material.

THATCH - A tightly intermingled layer of living and dead stems, leaves, and roots of grasses.

TIDAL BANKS - Vertical or sloping banks adjoining ocean's, rivers, bays, estuaries, etc. which are affected by fluctuations of daily tides.

TIME OF CONCENTRATION - Time required for water to flow from the most remote point of a watershed, in a hydraulic sense, to the outlet.

TOE (OF SLOPE) - Where the slope stops or levels out. Bottom of the slope.

TOE WALL - Downstream wall of a structure, usually to prevent flowing water from eroding under the structure.

TOPSOIL - Presumably fertile or desirable soil material used to topdress roadbanks, subsoils, parent material, etc.

TRAP EFFICIENCY - The capability of a reservoir to trap sediment. The ratio of sediment trapped to the sediment delivered, usually expressed in percent.

TRASH RACK - Grill, grate or other device at the intake of a channel, pipe, drain or spillway for the purpose of preventing oversize debris from entering the structure.

TUBERS - A thickened, short, usually subterranean stem having numerous buds called eyes; like a potato.

TUFTS - Having a cluster of hairs or other slender outgrowths; stems in a very close cluster.

TWIGGY - Having many fine branching stems; refers to woody shrubs or trees.

TWINING (VINE) - Ascending by coiling around a support.

UNHULLED (SEED) - Seed still encased with a hull. Example: Sericea lespedeza before it is rendered hulless by mechanically removing the hull.

UNIFIED SOIL CLASSIFICATION SYSTEM (ENGINEERING) - A classification system based on the indentification of soils according to their particle size, gradation, plasticity index and liquid limit.

UNIFORM FLOW - A state of steady flow when the mean velocity and cross-sectional area are equal at all sections of a reach.

UNIVERSAL SOIL LOSS EQUATION - An equation used for the design of water erosion control system: A=RKLSCP wherein A is average annual soil loss in tons per acre per year; R is rainfall factor; K is soil erodibility factor; L is length of slope; S is percent of slope; C is cropping and management factor; and P is conservation practice factor.

UPLIFT (HYDRAULICS) - The upward force of water on the base or underside of a structure.

UREAFORM - URAMITE - UREAFORMALDEHYDE - A slowly soluble synthetic organic fertilizer containing 38 percent nitrogen which contains about 30 percent readily available nitrogen.

VARIETY - A variant within a species which reproduces true by seed or vegetative propagation as applicable.

VELOCITY HEAD (HYDRAULICS) - Head due to the velocity of a moving fluid, equal to the square of the mean velocity divided by twice the acceleration due to gravity (32.16 feet per second per second).

WATER SURFACE PROFILE (HYDRAULICS) - The logitudinal profile assumed by the surface of a stream flowing in an open channel; the hydraulic grade line.

WEEP-HOLES (ENGINEERING) - Openings left in retaining walls, aprons, linings or foundations to permit drainage and reduce pressure.

WETTED PERIMETER (HYDRAULICS) - The length of the line of intersection of the plane of the hydraulic cross-section with the wetted surface of the channel.

WINDTHROW - State of being blown over by wind. Caused by shallow, pancake-like root systems, in most cases.

WING WALL - Side wall extensions of a structure used to prevent sloughing of banks or channels and to direct and confine overfall.

WINTERKILL - Killed by low temperatures during winter months.

WOOD FIBER - A short fiber mulch material, usually applied with a hydro-seeder in an aqueous mixture.

SECTION VII

NATURAL RESOURCES LAW

Section 8; Subtitle 11. Sediment Control.

§8-1101. Legislative findings; criteria and procedures to implement control programs.

The General Assembly determines and finds that lands and waters comprising the watersheds of the State are great natural assets and resources. As a result of erosion and sediment deposit on lands and in waters within the watersheds of the State, these waters are being polluted and despoiled to such a degree that fish, marine life, and recreational use of the waters are being affected adversely. In addition the General Assembly finds and declares that land movement and disturbance activities on Atlantic coast beaches east of certain natural and physical contours and elevations of the beach endangers the integrity and continuity of the beach system which includes a dunal system, prevents adequate maintenance, shore erosion and sediment control, and storm protection of these and adjacent areas, and results in the imposition of additional financial burdens on the citizens of the State. To protect the natural resources of the State, the Secretary shall adopt criteria and procedures for the counties and the local soil conservation districts to implement soil and shore erosion control programs. These procedures may provide for Departmental review and approval of major grading, sediment and erosion control plans.

REVISOR'S NOTE

Subsection 1101 is set out above just as it appears in Ch. 91, Acts 1975, 1st Sp. Sess.

§8-1102. Exemptions from subtitle.

The provisions of this subtitle do not apply to agricultural land management practices, construction of agricultural structures, or, except in Calvert County, to construction of single-family residences or their accessory buildings on lots of two acres or more. Regardless of planning, zoning or subdivision controls, a county or municipality may not issue a permit for grading or construction of any building, other than those matters exempted by the provisions of this section, unless the grading or construction conforms with plans approved as provided in this subtitle. (An. Code 1957, Art. 96A, §107; 1973, 1st Sp. Sess., Ch. 4, §1.)

REVISOR'S NOTE

This section presently appears as Article 96A, §107 of the Code. New language has been added to emphasize that a county or municipality may issue a permit only for those matters exempted by this section and not for matters exempted by county ordinances. The only other changes made are in style.

§8-1103. Grading and building permits; grading and sediment control plan; certification by developer; authority and responsibility of department and soil conservation district; grading and building ordinances.

(a) A county or municipality may issue grading and building permits as provided by law. A grading or building permit may not be issued until the developer (1) submits a grading and sediment control plan approved by the appropriate soil conservation district, and (2) certifies that all land clearing, construction, and development will be done under the plan. Criteria for sediment control and the procedure for referring an applicant to the appropriate soil conservation district shall be acceptable to the soil conservation district and the department. The county or municipality unit responsible for on-site inspection and enforcement of the provisions of this subtitle shall make a final inspection and forward its report to the appropriate soil conservation district. Notice of violations of the provisions of this subtitle shall be filed with both the department and the appropriate county unit.

REVISOR'S NOTE

This subsection presently appears as Article 96A, §108 (a) of the Code. The only changes made are in style.

(b) Each county or municipality shall adopt grading and building ordinances necessary to carry out the provisions of this subtitle, with the assistance of the department and the appropriate soil conservation district.

REVISOR'S NOTE

This subsection presently appears as Article 96A, §108 (b) of the Code. The last two sentences are proposed for deletion as obsolete. The references to portions of grading and building ordinances are unnecessary language and thus, are proposed for deletion. The last sentence is proposed for deletion because any ordinance speaks for itself. Reference to municipality is added to conform with other sections of this subtitle which refer to both counties and municipalities. The only other changes made are in style.

(An. Code 1957, Art. 96A, §108; 1973, 1st Sp. Sess., Ch. 4, §1.)

§8-1104. Land clearing, soil movement and construction - In general.

(a) Review and approval by soil conservation district. - Before any person clears, grades, transports or otherwise disturbs land for any purpose including, but not limited to, constructing buildings, mining minerals, developing golf courses, or constructing roads and streets, the appropriate soil conservation district first shall receive, review, and approve the proposed earth change. Land clearing, soil movement, and construction shall be carried out in accordance with the written recommendations of the soil conservation districts regarding control of erosion and siltation and elimination of pollution.

REVISOR'S NOTE

This subsection presently appears as Article 96A, §106 (a) of the Code.

The word "person" is defined in §8-101 (h). Reference to "State agency", however, is proposed for deletion because §8-1105 clearly exempts any state agency from the provisions of this subsection. The only other changes made are in style.

(b) Rules and regulations for erosion and siltation control in Prince George's and Montgomery Counties. - In Prince George's and Montgomery Counties, the Washington Suburban Sanitary Commission, after consultation with and advice of the soil conservation districts of the two counties and the department, shall prepare and adopt rules and regulations for erosion and siltation control requirements for utility construction. The rules and regulations shall be adopted and enforced as are others of the commission under authority conferred by other laws. These rules and regulations apply to any contractor doing work for the Washington Suburban Sanitary Commission. Utility construction may not be undertaken in Montgomery County until an erosion and sediment control plan is submitted to and approved by the Washington Suburban Sanitary Commission. After the county reviews and approves the plans, the commission may issue a permit for construction. In every case conditions of any permit granted for work performed in Montgomery by any contractor doing work for the Washington Suburban Sanitary Commission and by any public service company, as defined in §2, Article 78, of the Code may not be less stringent than standards incorporated into the provisions of any grading or building law or ordinance adopted pursuant to §8-1103 of this subtitle. Montgomery County shall inspect and enforce the conditions of the approved plans and permits. The provisions of this subsection do not apply until the soil conservation district in the county approves erosion and siltation control requirements for utility construction in that county.

REVISOR'S NOTE

This subsection presently appears as Article 96A, §106(b) of the Code. The only changes made are in style.

(An. Code 1957, Art. 96A, §106; 1973; 1st. Sp. Sess., Ch. 4, §1.)

Editor's Note. - Subsection (b) is set out above just as it appears in Ch. 4, Acts 1973, 1st Sp. Sess.

§8-1105. Same - Approval by department when undertaken by state unit.

The provisions of §8-1104 do not apply to any state unit. If a state unit undertakes any land clearing, soil movement, or construction activity, the department shall review and approve this action. (An. Code 1957, Art. 96A, §106; 1973, 1st Sp. Sess., Ch. 4, §1.)

REVISOR'S NOTE

This section is new language derived from Article 96A, §106(d) of the Code.

§8-1105.1. Beach Erosion Control District.

(a) A beach erosion control district is created which consists of that land bordered on the north by the boundary line between the state of Maryland and the state of Delaware, bordered on the east by the waters of the Atlantic Ocean, bordered on the south by the borderline between the state of Maryland and the state of Virginia, and bordered on the west by a line which coincides,more or less, with the west crest of the existing natural dune on Assateague Island, and in Ocean City, is a mutually approved line to be known as the State-Ocean City Building Limit Line which coincides, more or less, with the existing Ocean City Building Limit Line and on occasion my coincide with the crest of the littoral system. The department, after surveying, platting and recording the State-Ocean City Building Limit Line, has the authority to describe by regulation the State-Ocean City Building Limit Line. The department shall perform the survey, platting and recording at its own expense within 30 days of the effective date of this act.

(b) For the purposes of maintaining the Atlantic Coast beaches of the state and the beach erosion control district, the integrity and continuity of the dunal system and assuring adequate maintenance thereof, to provide for shore erosion and sediment control and storm protection, and to minimize structural interference with the littoral drift of sand and any anchoring vegetation, any land clearing, construction activity, or the construction of placement of permanent structures within the beach erosion control district is prohibited. This prohibition does not apply to any project or activity approved by the department and the appropriate soil conservation district specifically for storm control, beach erosion and sediment control, and maintenance projects designed to benefit the beach erosion control district.

(c) If the prohibitions imposed on the beach erosion control district would constitute a taking of a property right without just compensation in violation of the constitution of the United States or the constitution of Maryland, funds under program open space may be used to purchase or otherwise pay for any property taken.

(d) The provisions of this section are in addition to the provisions of Section 8-1103 and Section 8-1104.

REVISOR'S NOTE

Subsection 1105.1 is set out above just as it appears in Ch. 91, Acts 1975, 1st Sp. Sess.

§8-1106. Department to assist soil conservation districts.

The department shall assist soil conservation districts in preparing and implementing a unified sediment control program under this subtitle. (An. Code 1957, Art. 96A, §106; 1973, 1st Sp. Sess., Ch. 4, §1.)

REVISOR'S NOTE

This section presently appears as Article 96A, §106 (c) of the Code. The final sentence is proposed for deletion because it is obsolete. Chapter 348, Acts of 1972, abolished the Department of Water Resources and vested its responsibilities in the Secretary of the Department of Natural Resources. The Secretary has the authority to delegate responsibilities of units within the Department of Natural Resources. See proposed §1-104 (c) of this article. The only other changes made are in style.

§8-1107. Municipalities not within soil conservation district.

For the purposes of this subtitle, the bureau of public works or a similar municipal unit shall act in place of the appropriate soil conservation district in any municipality not within a soil conservation district. (An. Code 1957, Art. 96A, §110; 1973, 1st Sp. Sess., Ch. 4, §1.)

REVISOR'S NOTE

This section presently appears as Article 96A, §110 of the Code. The only changes made are in style.

§8-1108. Violations and penalties; injunctive relief.

(a) Any person who violates any provision of this subtitle is quilty of a misdemeanor, and upon conviction in a court of competent jurisdiction is subject to a fine not exceeding $5,000 or imprisonment not exceeding one year or both for each violation with costs imposed in the discretion of the court.

(b) Any agency whose approval is required under this subtitle or any interested person may seek an injunction against any person who violates or threatens to violate any provision of this subtitle. (An. Code 1957, Art. 96A, §109, 1973, 1st Sp. Sess., Ch. 4, §1.)

REVISOR'S NOTE

This section presently appears as Article 96A, §109 of the Code. The word "person" as used in the section is covered by §8-101 (h). The penalty provision in subsection (a) is retained despite the uniform penalty in §8-1501 because it is more severe. The only other changes made are in style.

SECTION VIII

SAMPLE SEDIMENT CONTROL PLAN REQUIREMENTS AND CHECKLIST

Requirements for Sediment Control Plans
Submitted for _______________ Soil Conservation District Approval

Area covered by Sediment Control Plan must be adequately located on a vicinity map. It must further be delineated and identified by project name as shown on record plat. All plans submitted for approval must be accompanied by a completed Form-IF-1. Information required on this form will be furnished by developer and/or his engineer.

SITE PLAN

The site plan shall include the existing and proposed topography. Existing topography can be either actual field survey or from information obtained from responsible agencies such as M-NCPPC. No proposed slopes will exceed 2:1. All slopes steeper than 3:1 will require low maintenance stabilization.

The existing and proposed improvements shall be shown on the site plan and will include all buildings, roads, storm drains, etc. that are existing as well as all proposed improvements. Proposed removal or alterations of existing facilities shall be indicated on the site plan.

The 50-year floodplain shall be delineated. No fill or permanent structures are permitted within the confines of the 50-year floodplain without prior approval from the Maryland Water Resources Administration where the contributing drainage area exceeds 400 acres.

STREET PROFILES

On projects where streets are to be graded, street profiles must be furnished. Include the location and spacing of interceptor dikes, the location of diversion dikes, and the location of outlets for the dikes. Provide information describing the condition below the outlets, to include existing vegetation, slope, and the method of stabilizing the outfall area where necessary.

SEDIMENT CONTROL PLAN

All sediment control practices must be identified on the Sediment Control Plan. These practices will be shown in sufficient detail to facilitate implementation. All permanent sediment control structures will be labeled on the plan as PERMANENT. All temporary stabilization practices will be labeled on the plan as TEMPORARY. The location and methods of stabilization will be indicated on the plan. Include method of proposed stabilization (vegetative or structural), what type of stabilization (sodding, g.s.s., seed/mulch, low maintenance vegetation, etc.), and locations of these practices. "Standards and Specifications for Soil Erosion and Sediment Control in Developing Areas" will be used as the guideline for proper terminology and design.

A schedule, or sequence, of operations will be included on the Sediment Control Plan. Special emphasis will be placed on scheduled start of clearing and/or grading, sequence of installation of sediment control and storm water management facilities, duration of exposure, and the scheduled start and completion dates of critical area stabilization (both temporary and permanent).

SEDIMENT BASINS

On projects incorporating sediment basins, the information contained on pages 19.08 and 19.09, Standards and Specifications, will be required. Supporting computations will be furnished on a design data sheet similar to the one in Appendix A-19 of the Standards and Specifications. Additionally, state on the plan the provisions for stabilization of the structure, and the elevation at which cleanout is required.

STORM DRAINAGE STUDY

A storm drainage study will be submitted with each project. Delineate subdrainage areas within the subject tract (as well as portions outside the tract). Indicate "C" factor and peak rate of runoff (Q_{10}) for any off-site drainage areas entering the site based upon future development at existing zoning.

STORM DRAINAGE PLAN

Provide a storm drainage plan. Show plan view and profile of storm drain outfalls to existing publicly maintained systems or natural stream channels. Indicate the velocity for 1) pipe outfall, 2) outfall structure, and 3) natural or designed channel below outfall structures to point of entry into existing system or natural stream. Show on plan the proposed method of stabilizing the outfall consistent with computed velocities.

ON-SITE STORM WATER MANAGEMENT PLAN

On projects requiring on-site storm water management, show the proposed method of retention or detention. Provide computations to show the required storage, the design storage capacity, and the proposed release rate. In addition, show the provisions for Q_{10} overflow. State on plan the responsibility for maintenance. On projects incorporating infiltration devices, a certified soil investigation is required. The following example is acceptable:

I hereby certify that on-site investigation has indicated that neither hard bedrock nor groundwater will interfere with installation and operation of the proposed storm water infiltration devices.

Signature	Registration Number	Date

Form-IF-1 (SAMPLE INFORMATION SHEET)

TO: __(blank)______ Soil Conservation District ______________
Address ____________________________________ Date

Gentlemen:

The enclosed Sediment Control Plan, supporting documents, drawings and computations are respectfully submitted for your approval.

Record Plat Title:________________
____

Type Zoning:____________________

Size of Tract:__________________

Preliminary Plan (M-NCPPC #1 - and date of approval)____________
____

Owner(s):_______________________

Address:________________________
____

Phone:__________________________

Soil Information:
Locate property boundaries on Soil Survey Sheet and provide copy, OR, indicate Sheet Number and list symbols:______________
____

Jurisdiction (check one):
County__________________________
City____________________________
Other (specify)_________________

Utilities (check appropriate space space):
Sewer (___public or ___private)
Water (___public or ___private)

On-Site Storm Water Management System Includes:________________
____

Scheduled Start of Grading:__________

Scheduled Completion of Storm Drainage, Paving and/or Stabilization:__________

Sediment Control Practices Planned:
Grading options:
__Limited initial grading (designate areas)____________________________
____

__Delayed site (or lot) grading
__Delayed finish grading
__Total site grading initially

Erosion Control Devices (use proper nomenclature - permanent structures to be so indicated on drawings):
__Diversion Dikes
__Interceptor Dikes
__Grade Stabilization Structure(s) (specify flume, flexible down drain, etc.)
__Level Spreaders
__Grassed Waterways (or ditches)
__Diversions
__Sediment Traps
__Sediment Basin (specify number_____)
__Other_____________________________
____
____

Critical Area Stabilization (Identify areas on plan):
__Structural (crushed stone, paving, etc.)
__Vegetative (temporary, permanent or mulch only)

Plans Prepared By:
____
____
____
(Phone No.) (Address)

CHECK LIST REVIEW FORM

Re:

Your submission is (acceptable) (not acceptable) for District approval as per the following check list. Technical review supplied by the Soil Conservation Service.

LEGEND
✓ - accepted
INC - incomplete
NA - not applicable

____ Area covered by Sediment Control Plan adequately located, delineated and identified.
____ Form-IF-1

SITE PLAN
____ Existing and proposed topography
____ Existing and proposed improvements
____ Floodplain delineated (no fill or permanent structures permitted in 50-year floodplain without prior Maryland Water Resources Administration approval)
____ Proposed slopes (none to exceed 2:1)

STREET PROFILES (as appropriate)
____ Location and spacing of interceptor dikes
____ Location of diversion dikes
____ Outlets for dikes (conditions - structures needed?)

SEDIMENT CONTROL PLAN
____ Proper identification of planned practices (in accordance with titles in "Standards and Specifications for Soil Erosion and Sediment Control in Developing Areas."
____ Label all permanent sediment control structures as PERMANENT
____ Label all temporary stabilization practices as TEMPORARY
____ Locations and methods of stabilization
____ Sequence of operations
____ Sediment basin (see attached Form-CL-2-SB)

STORM DRAINAGE STUDY
____ Subdrainage areas (including portions outside subject tract)
____ Off-site drainage areas entering site showing area, C factor and Q_{10}

STORM DRAINAGE PLAN (including plan view of storm drain outfalls to existing systems or stream channels)
Conditions at and below proposed Outfall Structures (after development- including Q10, crossections and profiles)
____ Proposed method of outfall channel stabilization
____ Pipe outfall (velocity)
____ Outfall structure (velocity)
____ Natural or designed channel below outfall structure (velocity)

On-Site Storm Water Management Plan

____ On-site detention (or retention) storage capacity (provide computations)
____ Proposed release rate (provide computations)
____ Provision for Q10 overflow
____ Provision for maintenance
   (a) Public maintenance
   (b) Private maintenance
____ Certified soil investigation for proposed infiltration devices

Storm Frequency Controlled

Storage;_____________ yr.
Release;_____________ yr.

Remarks:

Technical Review By:__________________

Date:__________________

Re:

SEDIMENT BASIN

____ Specific location of dam
____ Plan view of dam and the storage basin
____ Cross section of dam and emergency spillway
____ Profile of emergency spillway
____ Runoff calculations for 10-year storm
____ Calculations showing design of pipe and emergency spillway
____ Volume computations (stated in acre feet)
    ____ Total required (acre feet)
    ____ Total available (acre feet)
    ____ Required cleanout elevation
____ Sediment Basin Design Data Sheet
____ Provisions for stabilization

SEDIMENT CONTROL PLAN REQUIREMENTS FOR SHORE EROSION PROJECTS

______________________ ______________ __________
Name of Applicant(s) Phone Number SCD Number

____
Address (Street) (City) (State) (Zip)

______________________ ______________________
Consulting Firm Representative

____
Address (Street) (City) (State) (Zip)

SITE CONDITIONS

_________ Location of existing buildings, drains, septic systems
_________ Condition of existing bank (stable or unstable)
_________ Existing seeps, springs - show location
_________ Sandstone, shell outcropping, or any possible problem that causes stabilization failures
_________ Vicinity sketch
_________ Property line survey
_________ Acreage (Total)
_________ Description of predominate soil types
_________ Drainage patterns effecting site

SITE DEVELOPMENT

_________ Acreage to be vegetatively stabilized
_________ Indicate areas to be vegetatively stabilized
_________ Scale
_________ Legend
_________ Borrow - trucked in, dredged, or dragline
_________ Access road - temporary or permanent - show protection for life of road
_________ Cross-sections of bank (number depends on site)
_________ Proposed and existing contours
_________ Cut and fill slopes benched as needed - 15' vertical interval, reverse bench
_________ Provisions for protecting slopes from surface runoff
_________ Drainage plan and computations for drainage systems to convey water over bank
_________ Drainage area map
_________ Indicate areas on plan that are to receive approval for sediment control (where site will not undergo complete renovation)
_________ Ground water control where needed
_________ Yardage cut and fill

SEDIMENT CONTROL PLAN REQUIREMENTS FOR SHORE EROSION PROJECTS
(continued)

PHASING (Scheduling, sequence)

_________ Phase #1 - Construct bulkhead, wood, stone, gabion, or other
_________ Phase #2 - Remove all building materials, stumps, trees from behind bulkhead before backfilling
_________ Phase #3 - Backfill with organic free soils. Remove trees from bank, shape bank, bench terraces, tile drains for spring and seeps, surface drains, retaining walls, etc. (where needed)
_________ Phase #4 - Lime, fertilize, mulch, and seed. Analysis and rate per 1,000 square feet
_________ Phase #5 - Maintenance

DETAILS (with dimensions)

_________ Seedbed preparations
_________ Permanent seed
_________ Mulch
_________ Sod installation
_________ Fertilizer, amount and type
_________ Lime, amount and type
_________ Diversion
_________ Borrow - source of material - trucked in or dredged
_________ Haul and access road - temporary or permanent. Show protection for life of road
_________ Reverse bench slope
_________ Temporary sediment control measures
_________ Outlet protection
_________ Subsurface drain
_________ Bulkhead (timber, stone, etc.)
_________ Note M.L.W. and M.H.W.
_________ Systems needed to convey water from top of bank to lower levels (e.g., from bench terraces to proper outfall)

GENERAL

_________ Certification signed by owner/developer
_________ Plan sealed by P. E.
_________ Completion note sent to ___(blank)____ Soil Conservation District
_________ Plans developed by Government agencies will be so noted and signed by approving officials. Specifications will accompany plan submittals to the ___(blank)____ Soil Conservation District

SECTION IX

REFERENCES

REFERENCES

1. Meyer, L. D., "Unpublished Notes", Agricultural Engineer, Agricultural Research Service, USDA, Sedimentation Laboratory, Oxford, Mississippi.

2. Interstate Commission on the Potomac River Basin, "Urban Sediment Can be Controlled". Proceedings of Winter Meeting, February 17-18, 1966.

3. U. S. Department of Interior, Geological Survey. "Sediment Movement in an Area of Suburban Highway Construction, Scotts Run Basin, Fairfax County, Virginia 1961-64 Water Supply Paper No. 1541-E 1960.

4. U. S. Department of Housing and Urban Development. "Proceedings of the National Conference on Sediment Control, Washington, D.C., September 14-16, 1969". May 1970.

5. E.P.A., Office of Water Programs, Washington, D.C. "Control of Sediments Resulting From Highway Construction and Land Development".

6. U. S. Department of Interior, Geological Survey, "Hydrology for Urban Land Planning - A Guidebook on Hydrologic Effects of Urban Land Use". Circular 554, 1968.

7. USDA, Agricultural Research Service, "Predicting Rainfall-Erosion Losses from Cropland East of the Rocky Mountains", Agriculture Handbook No. 282, 1965.

8. Maryland State Highway Administration, "Specifications for Materials, Highways, Bridges, and Incidental Structures", Baltimore, Maryland, 1968.

9. American Association of State Highway and Transportation Officials, "Standard Specifications for Highway Materials", Washington, D.C., 1970.

10. USDA-SCS, "Maryland Engineering Memorandum No. 2, Earth Dams and Impoundments", 1972.

11. USDA-SCS, "Standard and Specifications No. 378, Ponds", SCS Field Office Technical Guide.

12. Brune, Gunnar M., "Trap Efficiency of Reservoirs", Transactions of the American Geophysical Union, Vol. 34, No. 3, pp. 407-418, June 1953.

13. Boysen, Stephen M., "Predicting Sediment Yield in Urban Areas", Proceedings National Symposium on Urban Rainfall and Runoff and Sediment Control, University of Kentucky, College of Engineering, 1974.

14. USDA-SCS, "Engineering Field Manual for Conservation Practices", 1969.

15. USDA-SCS, "Handbook of Channel Design for Soil and Water Conservation", Technical Paper No. 61, June, 1954.

16. Highway Research Board, "Design of Culverts, Energy Dissapators and Filter Systems", Highway Research Record No. 373, 1971.

17. Bohan, J. P., "Erosion and Riprap Requirements at Culvert and Storm Drain Outlets", U. S. Army Engineer, Waterways Experiment Station, Research Report No. H-70-2, January, 1970.

18. Fletcher, B. P. and Grace, J. L., Jr., "Practical Guidance for Estimating and Controlling Erosion at Culvert Outlets", U. S. Army Engineer, Waterways Experiment Station, Misc. Paper No. H-72-5, May, 1972.

19. National Academy of Sciences, Highway Research Board, "Tentative Design Procedure for Riprap-Lined Channels", National Cooperative Highway Research Program Report No. 108, 1970.

20. U. S. Army Corps of Engineers, Coastal Engineering Research Center, "Shore Protection Manual", 3 volumes, 1973.

21. USDA-SCS, "Maryland Drainage Guide", September, 1973.

22. USDA, Soil Conservation Service, Field Office Technical Guides.

23. Lawn Care in Maryland, Bulletin 171; Cooperative Extension Service, University of Maryland, College Park, Maryland.

24. Mulches for Wind and Water Erosion Control, USDA, ARS 41-84, July, 1963.

25. Applied Mulches and Mulching, USDA, ARS Special Report, ARS 22-71, August, 1961.

26. USDA, Soil Conservation Service Agriculture Handbook 296, "Land Resource Regions and Major Land Resource Areas of the United States".

27. Decker, Morris A., Midland Bermudagrass, Bulletin 465, University of Maryland Agricultural Experiment Station, January, 1959.

28. Deal, Elwyn E. and Newcomer, Joseph L., Agronomy Mimeo No. 70, University of Maryland Agronomy Department, May, 1967.

29. Guidelines Specifications, Soil Preparation and Sodding. MD-VA Pub. #1. Cooperative Extension Service, University of Maryland-Virginia Polytechnic Institute. Revised 1973.

30. Guideline Specifications for Sodding. American Sod Producers Association, Inc., New Brunswick, N.J.

31. Growing Ground Covers, USDA Home and Garden Bulletin No. 175.

32. Autumn Olive, USDA, Soil Conservation Service Leaflet No. 458.

33. Ground Cover Plants, Ext. Bull. 190, University of Maryland, College Park, Maryland.

34. Evaluation of Woody Plants and Development of Established Procedures for Direct Seeding and/or AW 73-75-46, for Maryland State Highway Administration by USDA, Soil Conservation Service.

35. State of New York, "The Conservationist", April - May, 1971, Pages 22-27.

36. Hill, David E. and Shearin, Arthur, " Tidal Marshes of Connecticut and Rhode Island", Agri. Experiment Station Bulletin 709, February, 1970.

37. Shore Erosion in Tidewater Maryland, 1949 Reprint from Bulletin 6, State of Maryland, Department of Natural Resources.

38. Slaughter, Turbit, "Vertical Protective Structures in the Maryland Chesapeake Bay", Shore and Beach Journal.

39. Agricultural Information Bulletin 285, "Protecting Trees Against Damage from Construction Work", Superintendent of Documents, U. S. Government Printing Office, Washington, D.C. 20402 - 15¢ a copy.

40. Guidelines for the Control of Erosion and Sediment in Urban Areas of the Northeast, USDA, Soil Conservation Service, Upper Darby, Pennsylvania, 1970.

41. Jones, J. N., Armiger, W. H., and Bennett O. L., "A Two-Step System for Revegetation of Surface Mine Spoils", Journal of Environmental Quality, Vol. 4, No. 2, 1975, pages 233-235.

42. Augustine, Marshall T., Thornton, Robert B., Sanborn, James M., and Leiser, Andrew T., "Response of American Beachgrass to Fertilizer", Journal of Soil and Water Conservation, May - June, 1964.

43. Thornton, Robert B., Davis, Arnold G., "Development and Use of American Beachgrass for Dune Stabilization", Presented at American Society of Agronomy Meeting, Kansas City, Mo., November, 1964.

44. Jagschitz, John A., and Wakefield, Robert C., "How to Build and Save Beaches and Dunes", University of Rhode Island, Marine Leaflet Series No. 4.

45. Jagschitz, J. A., and Bell, R. S., "Restoration and Retention of Coastal Dunes with Fences and Vegetation", Bulletin 382, January, 1966, Agricultural Experiment Station, University of Rhode Island, Kingston, Rhode Island.

46. Agriculture Handbook No. 60, "Diagnosis and Improvement of Saline and Alkali Soils", by United States Salinity Laboratory Staff.

47. "How to Treat Salt Damaged Land", University of Maryland, Agronomy Department, Agronomy Mimeo No. 8, Rev., May, 1962.

48. "Wind Erosion Forces in the United States and Their Use in Predicting Soil Loss", Agriculture Handbook 346.

49. "How to Control Wind Erosion", USDA-ARS, Agriculture Information Bulletin 354.

50. Soil Conservation Society of America, "Resource Conservation Glossary", 1970.

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The people whose names appear below met as an ad hoc committee to work on the Vegetative Standards and Specifications and the Vegetative material in the Appendix of this publication. From the U. S. Soil Conservation Service were Harold V. Stephens, Conservation Agronomist, College Park, Maryland, and H. Wayne Everett, National Plant Materials Center Manager, Beltsville, Maryland (Now Plant Materials Specialist, SCS, Lexington, Kentucky). From the University of Maryland Agronomy Department, College Park, Maryland, were Dr. Fred Miller, Dr. Lenat Hofmann, Dr. V. Aolan Bandel, Dr. A. Morris Decker, and Dr. John Hall. Other University of Maryland staff members were consulted. Richard C. Moffett, Chief Agronomist for the State Roads Administration, Maryland Department of Transportation and Marshall T. Augustine, Sediment control Specialist, for the Maryland Department of Natural Resources also assisted. Mr. Stephens was the coordinator and principal compiler for the vegetative section.

Harold E. Scholl, State Resource Conservationist for the Soil Conservation Service in Maryland provided overall coordination. He also designed the cover and the composite photographs and contributed to the introductory sections.

Typists were Thelma Wheeler, Deborah Hepburn and Sandy Ludka, SCS, College Park, Maryland.

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SECTION X

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